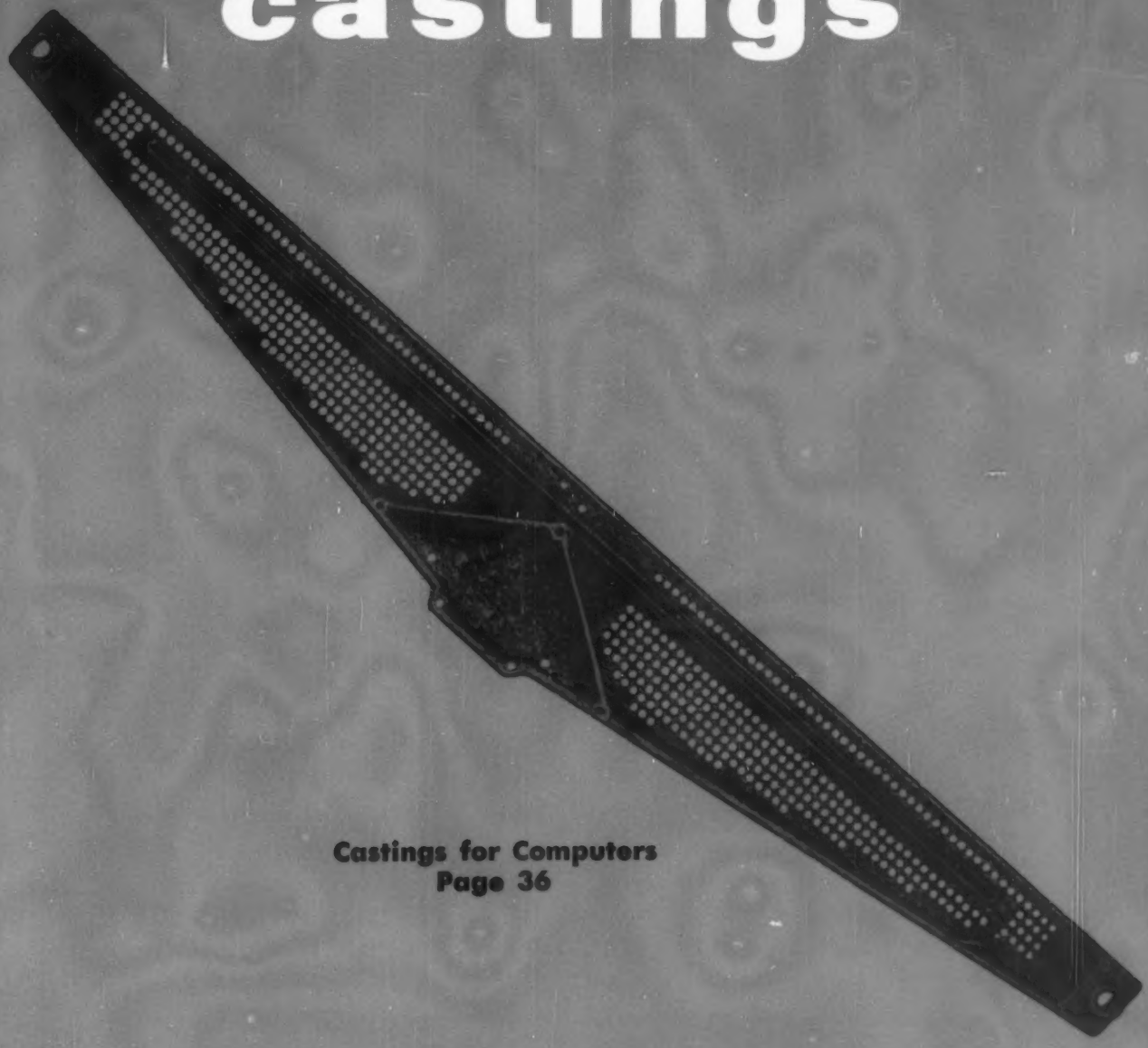
NOVEMBER 1960

modern castings



Castings for Computers
Page 36

New Market Opportunities for Steel Foundries 29

Squeeze the Safety Factor 44

New! Direct Reduction of Ore to Molten Metal 38

*PATENTS APPLIED FOR

"SUPER-STEEL"

STEEL SHOT *and* GRIT

$165.00

per ton
in truck loads

A revolutionary new process for producing steel shot makes it possible for METAL BLAST to offer substantial savings to *all plants using steel abrasives.* This new process turns out steel shot much more economically than the conventional process used by others — and savings are passed along to consumers!

"SUPER-STEEL" abrasives are strictly top quality and perform as top quality abrasives should — in cleaning action, in number of passes and effect on equipment. In fact, we'll give you a written, *money-back guarantee* that "SUPER-STEEL" will equal the performance of any steel abrasive now on the market.

Here's an opportunity to save many important dollars on steel abrasives. Why not at least investigate? Write, wire or phone (collect) for full information and sample.

METAL BLAST, INC.

873 EAST 67th STREET • CLEVELAND 3, OHIO • Phone: EXpress 1-4274

ALSO IN: Chattanooga • Chicago • Cincinnati • Dayton • Detroit • Elberton, Ga. • Grand Rapids • Greensboro, N. C.
Houston • Los Angeles • Louisville • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh and St. Louis.

MANUFACTURERS, ALSO, OF TOP QUALITY "SEMI-STEEL" SHOT AND GRIT, MALLEABLE AND CHILLED SHOT AND GRIT — AT COMPARABLE SAVINGS!

Circle No. 136, Pages 143-14

Why Foundries are Sold on

Carver RAPID MULLER

1 "We are using natural bonded sand in our plant and find the Carver Muller has cut down on bonding material better than 50%. We like the Muller very much."

— G. W. Manfull
West Coast Alloys Co.
Troutdale, Oregon

2 "The Carver does a good job for what it was designed. A low priced mixer. Small floor space and does a good job of mixing with CO_2 Sand."

— Nollan Williams, Vice President
Industrial Castings Division
James H. Mathews Co.
Pittsburgh, Pennsylvania

CHECK . . . COMPARE AND YOU'LL CHOOSE CARVER!

- **The fastest! A batch every 75 seconds!***
- **Only one moving part . . . no maintenance worries!**
- **Absolutely no lumps or wet spots!**
- **Easiest to clean! Just reach inside!**
- **3 times lower initial investment than with most mullers!**
- **Works equally well with any kind of binder!**

*Applies to CO_2 Sand. Oil sand may take up to three minutes.

Only Carver Has Everything For the CO_2 Process!

CARVER V & S Core Shooters

CARVER Automatic Gassing Apparatus

KRAUSS Taper Slot Core Vents

STEINEX available only from CARVER

MAIL COUPON TODAY

CARVER FOUNDRY PRODUCTS CO. M-5
Muscatine, Iowa

I want to compare! Tell me more about Carver Rapid Muller.

NAME _____ TITLE _____

FOUNDRY _____

CITY _____ STATE _____

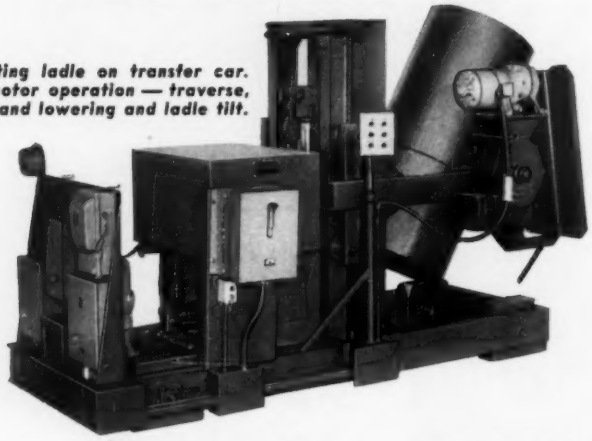
Circle No. 121, Pages 143-144

MODERN -WAYS PLUNGING INOCULATING

LADLES ENGINEERED TO YOUR NEEDS!

Plunging the alloy into the molten metal, holding down on the reaction and shielding the vaporization is a low-cost and highly profitable way to add magnesium for ductile iron. Other major advantages include:

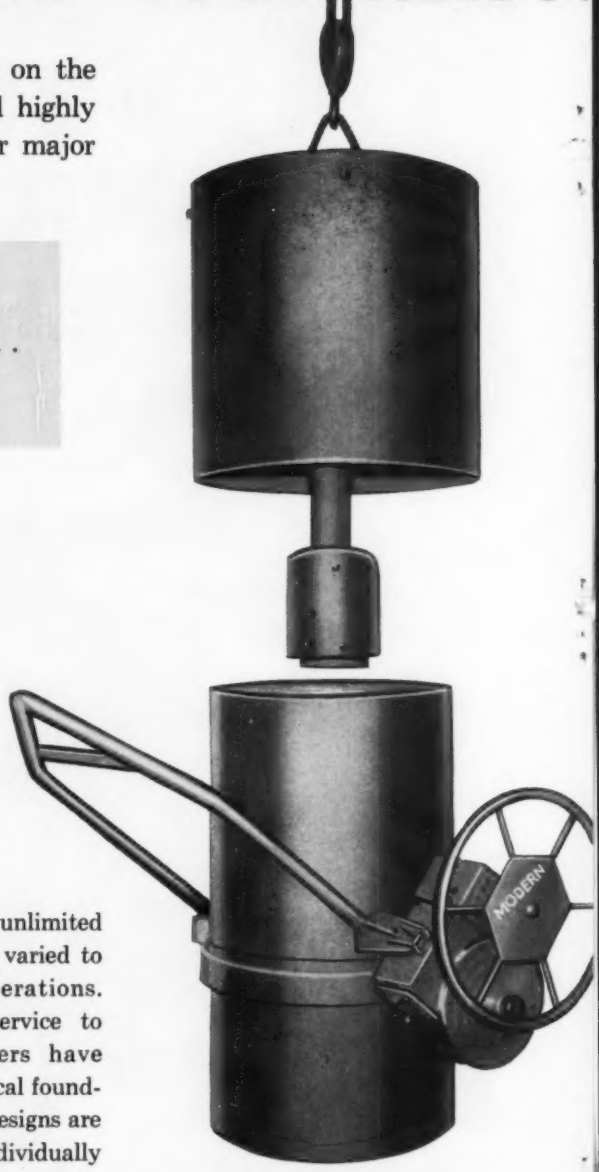
- *Higher percentage of magnesium recovery . . .*
- *Better analysis control . . .*
- *Less sparking, less smoke, less fume removal expense . . .*
- *Less slag, min., oxidation and cleaner iron . . .*
- *Lower, over-all alloying costs . . .*



Inoculating ladle on transfer car. Three-motor operation — traverse, raising and lowering and ladle tilt.

Motorized, inoculating ladle to treat 3500 pounds of nodular. 22", free top space for reaction area.

Engineered, ladle designs and unlimited capacities, for plunging, may be varied to serve your individualized operations. Throughout our forty-year's service to foundries, MODERN engineers have worked hand in hand with practical foundrymen. Now, MODERN, ladle designs are unlimited! Capacities, too, are individually engineered to the needs of your pouring floors. There's less chilling, less pigging and the higher pay-loads boost your take at the weigh-out scales. LADLES UNLIMITED include ladles with manual control, motorized-tilt, transfer cars, etc.! You name it! We'll make it!



Inoculating ladle with skirt and plunger-bell.

Ask for CATALOG P-152-A

MODERN EQUIPMENT COMPANY

Dept. F-10, Port Washington, Wisconsin

REPRESENTATIVES IN ALL PRINCIPAL CITIES

November 1960 Vol. 38, No. 5

modern castings

world-wide technical authority of the metalcasting industry

COVER

Drawn by CHARLES ROTH. Zinc Die Casting Breakthrough of 1960. Read "Casting for Computers," page 36

MANAGEMENT

New Market Opportunities for Steel Foundries: Seven Ways to Solve Steel Castings' Slow Growth Problems ..... JACK H. SCHAUM 29
Castings for Computers ..... JACK H. SCHAUM 36

TECHNIQUES

Is a New Concept Needed for Hot Sand Properties? ..... GEORGE J. VINGAS AND A. H. ZRIMSEK 33
New! Ore to Molten Metal by Direct Reduction ..... A. E. DE SY 38
How to Choose the Right Refractories ..... F. A. FANNING 42
Squeeze the Safety Factor, Allow Less Ignorance ..... T. O. KUIVINEN 44
Casting for Defense ..... M. L. SLAWSKY AND F. A. HEISER 47

CASTINGS CONGRESS PAPERS

Technical Highlights ..... S. C. MASSARI 54
Solidification Conditions for Maximum Density and Mechanical Properties in 85-5-5-5 Castings . . . Brass & Bronze Division Research Report by ..... R. A. FLINN AND H. KUNSMANN 55
Industrial Engineering in the Foundry Industry ..... M. T. SELL 65
Die Casting Die Steels Heat Treatment and Related Problems ..... D. R. EDGERTON AND N. O. KATES 73
Physical and Chemical Conditions Variation Effect on Bentonite Suspension Systems ..... A. J. ANDERSON AND G. J. SUTTON 88
Aluminum Alloy Test Bar Casting Temperature Effect on Properties ..... J. W. MEIER AND A. COUTURE 98
Molten Metal Handling in Die Casting Plants ..... VICTOR D. SWEENEY 110
Microscopic Test Coupons, Report of Ductile Iron Research Committee .. 117

NEWS OF THE INDUSTRY

Around the World 7
Convention News 121
Direct Reduction Makes Molten Metal Faster 122
National News 122
AFS Chapter News 127
How's Business 150

OPINION MAKERS AND OPINIONS

Need, Exclusiveness, Enterprise! ..... H. E. GREEN 5
Reader Opinions and Ideas 11
Is Organized Recreation Necessary? ..... H. F. DIETRICH 18
Select the Right Course ..... R. E. BETTERLEY 20
Din! Din! Din! ..... H. J. WEBER 23
Here's How 24
The Editor's Report ..... J. H. SCHAUM 152

SERVICES

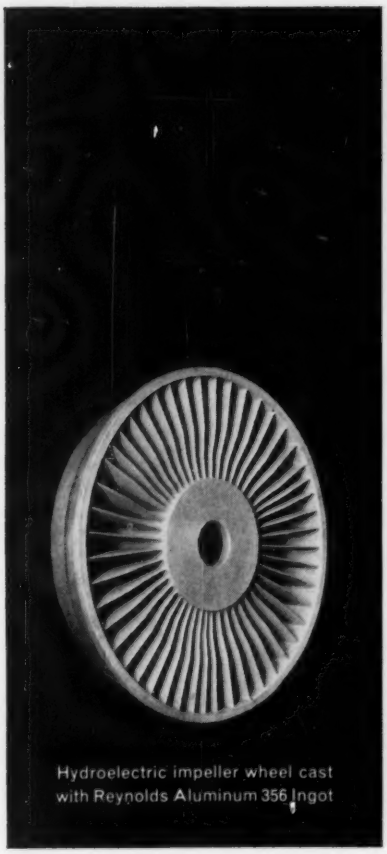
Chapter Meetings 133
Foundry Trade News 137
Personalities 138
Obituaries 139
Products & Processes 140
For the Asking 142
Literature Request Service 143
National Meetings 147
New Books for You 148
Classified Advertising 149
Advertising Index 149

DECEMBER ISSUE

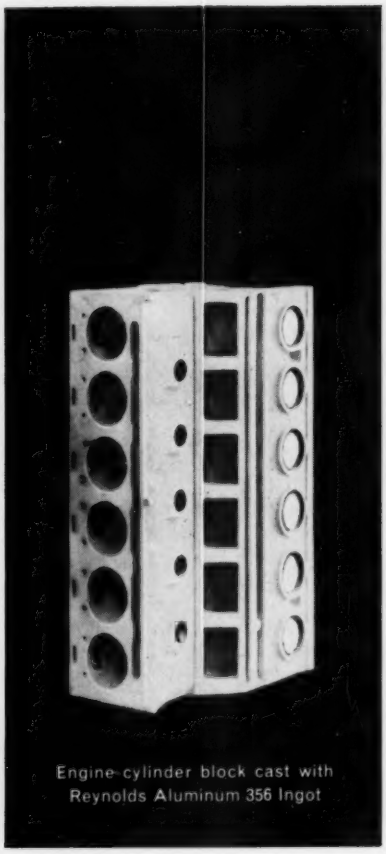
Machine Tools: A Survey of Market Opportunities .....
How Warner Swasey Uses Gray Iron Castings for Machine Tools .....
Cement Bonded Molding Sand Practices in East Germany .....

MODERN CASTINGS is indexed by Engineering Index, Inc., 29 West 39th St., New York 18, N. Y. and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich.
The American Foundrymen's Society is not responsible for statements or opinions advanced by authors of papers or articles printed in its publications.
Published monthly by the American Foundrymen's Society, Inc. Publication office: 1309 North Main Street, Pontiac, Illinois, U.S.A. Editorial and executive offices: Golf & Wolf Roads, Des Plaines, Illinois. Subscription price in the U. S., $5.00 per year; elsewhere, $7.50. Single copies 50¢. May and June issues $1.00. Second class postage paid at Pontiac, Illinois. Addition entry at Des Plaines, Illinois.

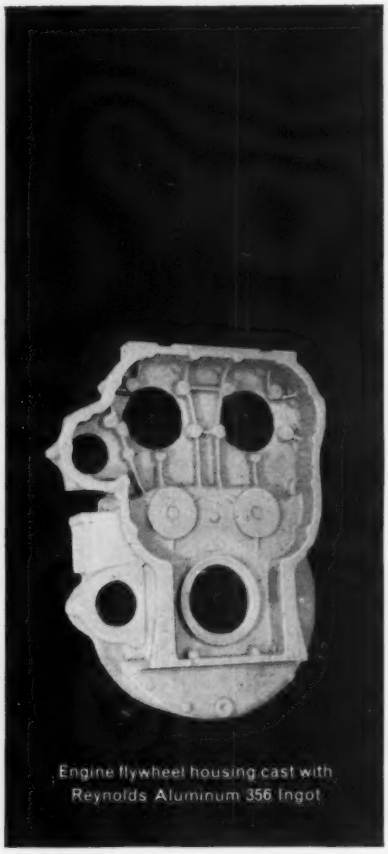
Circle No. 122, Pages 143-144



Hydroelectric impeller wheel cast with Reynolds Aluminum 356 Ingot



Engine cylinder block cast with Reynolds Aluminum 356 Ingot



Engine flywheel housing cast with Reynolds Aluminum 356 Ingot

Why Quality Aluminum Casting Company makes precision castings with Reynolds Aluminum 356 Ingot

Quality Aluminum Casting Company of Waukesha, Wisconsin has built a reputation based on their name—and they've done it over a forty year period by offering fine precision castings. Their metal: quality aluminum alloy ingot—Reynolds 356 Ingot.

Reynolds 356 Ingot is made from 100% virgin aluminum and top quality alloying elements. Impurities are held to an absolute minimum, far below published specifications. This control of the impurities is one of the reasons that our customers consistently report remarkable mechanical properties, far above standard in many cases. Each furnace charge is thoroughly cleaned, tested for correct chemical content, freedom from gas and oxides, grain-refined by addition of titanium and boron and then cast by Reynolds own "quick-chill" process.

Commercially acceptable 356 alloy can be made with a lot less fuss and bother but we think it is worth-while (and our customers whole-heartedly concur) to spend the extra time and effort to make each cast a metallurgical masterpiece.

When normally controlled foundry practices are used with Reynolds Casting Ingot, each and every part made will meet or exceed your highest expectations.

For more information on Reynolds Aluminum alloy ingot and your free copy of the new Reynolds manual, "Casting Aluminum", write to the *Reynolds Metals Company, P. O. Box 2346-FL, Richmond 18, Virginia.*

REYNOLDS ALUMINUM

Watch Reynolds new TV show "Harrigan & Son", Fridays; also "All Star Golf", Saturdays—ABC-TV

Circle No. 123, Pages 143-144

modern castings

Golf and Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181

Managing Director
HAROLD E. GREEN

Editor
JACK H. SCHAUM

Editorial Staff

DAVID GLENN, *Managing Editor*
GEORGE A. MOTT, *News Editor*
W. R. FINGAL, *Washington Editor*

S. C. MASSARI, *Technology*
H. J. WEBER, *Safety, Hygiene and Air Pollution Control*
R. E. BETTERLEY, *Education*
H. F. DIETRICH, *Industry*
C. R. MCNEILL *Castings Congress Papers*
M. C. HANSEN, *Castings Congress Papers*

Business Staff

GRETA MAXFIELD, *Advertising Sales Liaison*
MARY MCLEAN, *Advertising Production Manager*
DONNA PITKAT, *Reader Service*
MILDRED MICHELS, *Circulation Manager*

District Managers

DWIGHT EARLY & SONS CO.—Midwest
221 N. LaSalle St., Chicago 1
CEntral 6-2184

C. A. LARSON & ASSOC.—Eastern
254 W. 31st St., New York 1
LOngacre 4-4285

PIRNIE & BROWN—South-Southwest
722 Rhodes-Haverty Bldg., Atlanta 3
JAckson 2-8113

DON HARWAY & CO.—Western
1709 W. Eighth St., Los Angeles 17
HUbbard 3-5141

JOHN ASHCRAFT—European
67 Ave des Champs Elysees
Paris 8, France

Published by
American Foundrymen's Society

GENERAL MANAGER
WM. W. MALONEY

Let's look at...

NEED, EXCLUSIVENESS, ENTERPRISE!

Someone asked the other day why MODERN CASTINGS has suddenly mushroomed into the most important magazine in metalcasting today.

The answer was easy, as is the case with a leadership publication: NEED, EXCLUSIVENESS, and ENTERPRISE.

Profound changes are taking place in the structure of the metalcasting industry today. The key element is *technology for profit.* This has to be the *one big factor* if foundrymen are to remain competitive in many phases of casting.

Top management, middle management, and technicians are being drawn closer to a common meeting ground, *technology for profit.* This meeting ground is MODERN CASTINGS. Here business trends, news and technological advances are melded together as never before.

MODERN CASTINGS is NEEDED because it presents first, and EXCLUSIVELY every important, new technological advance in the field.

Through ENTERPRISE, the editorial content has taken on a new significance and meaning because a common meeting ground has been established *exclusively* as never before—*technology for profit.* The entire industry is represented editorially through leadership and enterprise.

A glance at this issue points this up:

On page 29 . . . Marketing opportunities for steel foundries, another in our industry leadership series.

On page 38 . . . A breakthrough article on direct reduction of ore to molten metal, plus a news article on a pilot operation here in the United States on the same approach.

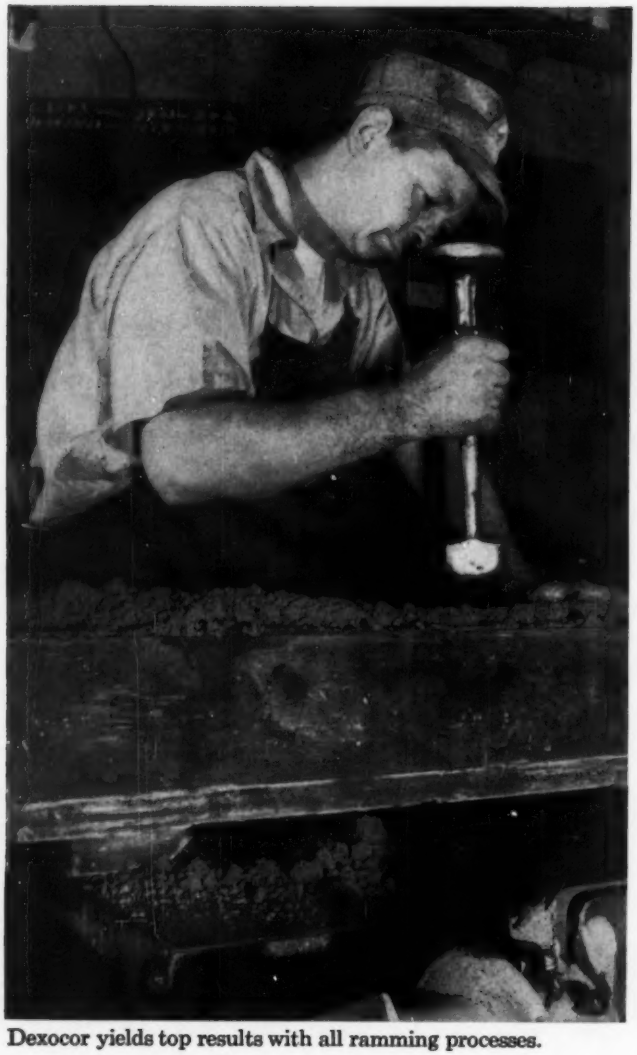
On page 44 . . . Squeeze the safety factor—allow less for ignorance.

There are other exclusive articles in this up-to-date, carefully coordinated issue. All deal with current needs and trends, and problems, of metalcasting.

There is no substitute for the exclusive material in MODERN CASTINGS, the enterprise of its staff, or the need that it fills today.

Harold E. Green

Save Up To 50% In Core Baking Time!



Dexocor yields top results with all ramming processes.

Use Dexocor binder, the amazing new binder for sand molds. Field reports show this *dry* replacement for core oil cuts baking time 30 to 50 percent!*

Savings of fuel dollars and more flexible production scheduling are only two of Dexocor's advantages. Among its other features are: faster mulling... low gas generation... excellent green strength ...high baked strength...uniform density ...easy shake-out...ready collapsibility.

Whether you make small or large castings, simple or intricate, you will profit by the properties of Dexocor. One foundry now uses it in 19 different sand and core mixes!

For the full facts on this amazing new binder and technical assistance in adapting it to your special needs, contact our nearest sales office or write direct.

*Source on request

DEXOCOR® binder

DEXOCOR® is the perfect teammate for MOGUL® and KORDEK® binders and GLOBE® dextrines

CORN PRODUCTS COMPANY INDUSTRIAL DIVISION • 10 East 56 Street, New York 22, N. Y.

Circle No. 124, Pages 143-144

Around the World with Modern Castings

AUSTRALIA

Polson Motor Parts Pty. Ltd. in Melbourne has installed a mains frequency (50 cycles per second) coreless induction furnace for producing gray iron. The new furnace melts metal for 1.4 pence per pound compared with cost of 2.1 when using indirect arc. Metallurgical control is easier than with any other melting unit. Linings are lasting for 170-180 heats. Some of the advantages include: 1) easy maintenance; 2) simple to operate; 3) lining easy to install; 4) low metallic losses; 5) chemical control is simple; 6) no sulphur pick-up; 7) metal can be heated and held at any temperature; 8) power load always steady; 9) power cost lower than for high frequency and arc furnaces. Many foundries, particularly in Europe, are turning to the use of this relatively new type of furnace for quality gray iron.

POLAND

Steel mills are taking a close look at ductile iron rolls with chilled surface as a replacement for conventional chilled gray iron rolls. In comparable billet rolling service, the ductile iron rolled 34,000—40,000 tons compared with 20,000-25,000 tons for the gray iron. The former contains 0.4-0.6 per cent chromium, 1.2-1.8 per cent nickel and is treated with 0.54 per cent magnesium. Further strength is gained by reducing carbon to 2.0 per cent. As a substitute for nickel, silicon can be raised to 2.1 per cent and manganese upped to 1.0 per cent This is a substantial gain in roll life and opens a sizeable market for ductile iron.

JAPAN

Speed first and second-stage graphitization of malleable iron. Reduce expensive fuel consumption and time in the furnace by adding calcium silicide. Also allows silicon to run even lower than 0.5 per cent. However, the calcium silicide does make it increasingly difficult for the iron to solidify as white iron in sand molds. For this reason its use may be limited to relatively thin-sectioned castings.

UNITED STATES

Foundries are on the threshold of a remarkable revolution which will strengthen their competitive tenet that metalcastings are the shortest line between raw materials and finished product. A direct reduction pilot plant has just been unveiled in Cleveland by the McDowell Co. Research sponsored by the McWane Cast Iron Pipe Co. has developed the Dwight-Lloyd McWane Process. It combines low initial equipment investment with ability to produce high-grade iron economically from low-grade raw materials in small or large tonnages. Read MODERN CASTINGS' news story on this important event on page 122. Also in this issue, on page 38, is a feature technical article describing a Belgian process for direct reduction of iron ore

to molten iron. This technique is unique in that it uses a double hearth induction furnace with carbon being added to the melt in one hearth and iron ore plus flux entering the other. Carbon combines with the oxygen in the ore to form CO gas and metallic iron.

SWEDEN

U. S. foundrymen just back from overseas report that several foundries in Sweden are proving that CO_2 process sand can be transported by pneumatic conveyors. In spite of incompatibility of air and sodium silicate, foundries have not found too much difficulty with premature hardening of the sand as result of using air conveyors.

ENGLAND

An efficient and thorough technique for removing insoluble particles from magnesium alloys has been announced recently by Magnesium Elektron, Ltd. The molten magnesium is poured into a filter box with a one-inch layer of chilled iron shot supported on a perforated steel plate. Impurities are removed by filtration as the metal flows through the bed. Shots should be 1/16 to 1/8 inch diameter. As a result the cast metal is substantially particle free and physical properties are proportionately improved.

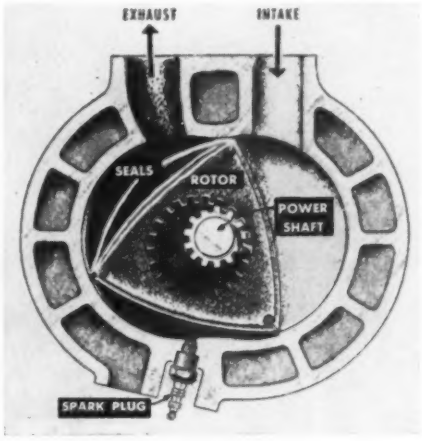
RUSSIA

So-called "transparent metals" may be just the answer to studying metal solidification phenomena. These transparent metals are halogen salts, such as silver chloride. They can be melted and poured like metal castings and they solidify as transparent crystals. Solid sections can be studied with polarized light which reveals internal casting stresses similar to metal castings. Foundry researchers should find this approach a real boon to solidification studies.

UNITED STATES

Curtis-Wright Corp. is working with the N S U Werke of Germany on a completely new concept of internal combustion engine—the Wankel engine.

It's a 29-horsepower rotary motor weighing only 27 pounds and has no valves, pistons, connecting rods, crankshaft nor reciprocating parts of any kind. The drum-shaped engine has a triangular rotor geared to the power shaft so it revolves off-center. The rotor turns in a circular chamber slightly flat at top and bottom. The three rotor corners follow the contours of the chamber so as to inhale fuel, compress, fire, and exhaust it. Experiments are underway for adapting the revolutionary design to automobile propulsion.



Rugged, lightweight Transite Core Plates add new speed to precision core production

Asbestos-cement composition resists shock, breakage, corrosion . . . is easily cleaned

More and more experienced foundrymen rely on sturdy, finely sanded Transite® Core Plates for the smooth, level surface needed to turn out top-quality cores in minimum production time. The unusually light weight of the boards makes them easy to handle . . . also helps step up production.

How can Transite Core Plates stay smooth and true, even during baking and drying? They're fabricated of fibrous asbestos and cement in a special Johns-Manville process. Year in and year out, the rugged material stands up with a minimum of warpage and wear. Boards resist shock and corrosion, won't crack or break under normal conditions. Surfaces can be easily cleaned, too.

Transite Core Plates have proved themselves in hundreds of ferrous and non-ferrous foundries all over the country. If you haven't already done so, why not give them a chance to go to work, profitably, in your operation?

Get all the facts—send for FREE new Transite Core Plates folder

Whether or not you now use Transite Core Plates, get our FREE new folder IN-219A today! It contains a wealth of helpful information—can make a contribution to *your* profit picture. Send the coupon below.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville, Box 14, New York 16, N.Y.
(In Canada, Port Credit, Ontario)
Please send me booklet IN-219A at no cost or obligation to me.

Name_____ Position_____

Firm_____

Address_____

City_____ Zone____ State_____

Circle No. 125, Pages 143-144

Steels and irons with "vitality" to spare...*start with Vancoram Ferrovanadium*

It takes only a small amount of Vancoram Ferrovanadium to impart *extra* strength and *extra* durability to a wide variety of steels and irons. Ferrovanadium controls grain size, improves hardenability, and is especially useful in tool and die steels because it provides excellent cutting and wearing characteristics. Constructional steels, deep-drawing steels, and cast and forged steels also benefit from Vancoram Ferrovanadium additions.

In cast irons, Ferrovanadium promotes formation of small, uniform graphite flakes, thus increasing tensile strength. Furthermore, the presence of vanadium carbide improves resistance to structural changes at elevated temperatures. Write for literature, or call your nearest VCA District Office. Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y. • Chicago • Cleveland • Detroit • Pittsburgh.

Vancoram Products are also distributed by: Pacific Metals Co., Ltd. • Steel Sales Corporation • J. M. Tull Metal and Supply Co., Inc. • Whitehead Metals, Inc. • Williams and Company, Inc.

VANADIUM
CORPORATION OF AMERICA
Producers of alloys, metals and chemicals

VANCORAM

Circle No. 126, Pages 143-144

Reader Opinions and Ideas . . .

MOTH BALLS AND FUMES

We have a foundry at South Altoona, Pa., which is just beginning to produce aluminum castings. The superintendent has asked us about the possibility of health hazards from the inhalation of fumes in the use of a proprietary material with a strong odor of chlorine. This material is added to molten aluminum to remove hydrogen before pouring.

Can you tell us whether any kind of health hazard has been associated with its use. We would appreciate having any printed material that is available and references to published articles.

JAMES F. MORGAN
Pennsylvania Railroad Co.
Philadelphia

Note: Degassers for aluminum are moth balls or carbon hexachloride. When subjected to high temperature the molecule disassociates and the chlorine atom reacts with the dissolved hydrogen in the molten aluminum to form HCl. If carbon monoxide is present, phosgene will form. In your foundry, I believe that at worst you have a nuisance from the camphor odor and the HCl gas.—Herbert J. Weber, Director AFS Safety, Hygiene, and Air Pollution Control Program.

REQUEST FROM ENGLAND

As a member of AFS I receive MODERN CASTINGS and was interested to read in the June issue the Charles Edgar Hoyt Memorial Lecture, "Where Do we Go from Here," and also "Gray Iron versus Aluminum."

We would like to circulate this information among our customers and executives and wondered if it would be possible to obtain about 20 reprints of each?

J. D. BERRY
Birmid Industries, Ltd.
Smethwick, Staffs,
England

Editor's Note: Twenty copies of each have been forwarded. Copies of these and many other MODERN CASTINGS *articles are available, for the asking.*

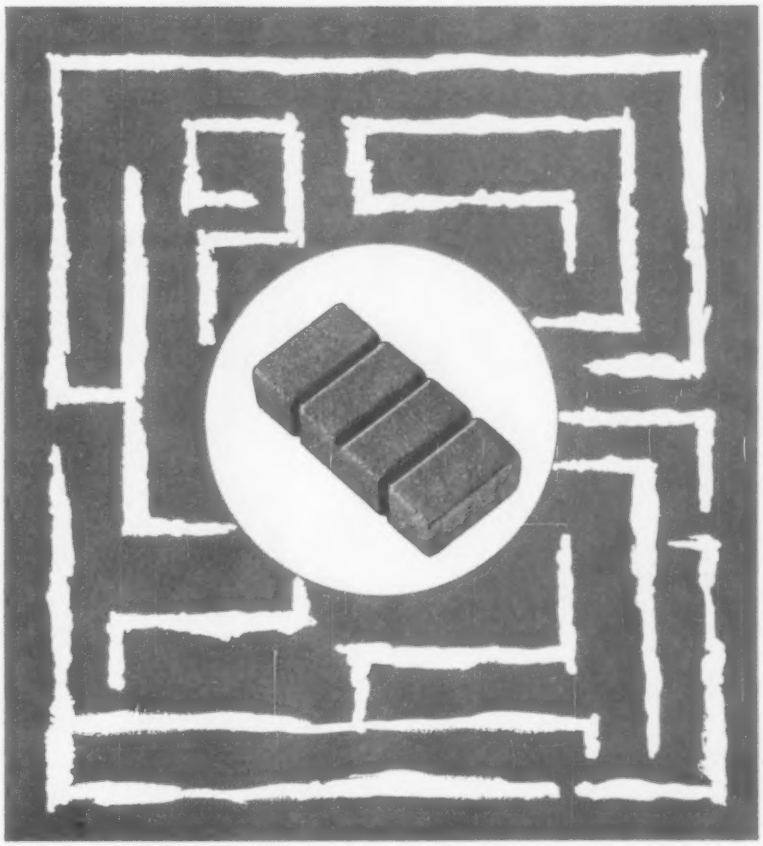
COPIES TO ACADEMIES

As I was leafing through the May, 1960 issue of MODERN CASTINGS, I noticed a letter from a midshipman

Continued on page 14

No matter where you start your best solution for cleaner iron is . . .

***Famous* CORNELL CUPOLA FLUX**
for Gray Iron and Malleable Iron Foundries



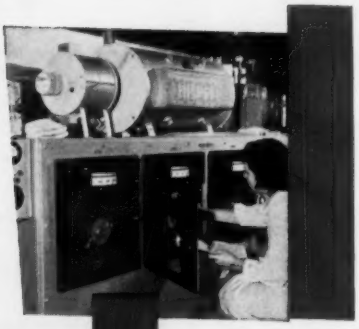
Have you tried Famous CORNELL Aluminum, Brass or Copper Flux? If you melt these metals, you should! . . . Write for Bulletin 46-A.

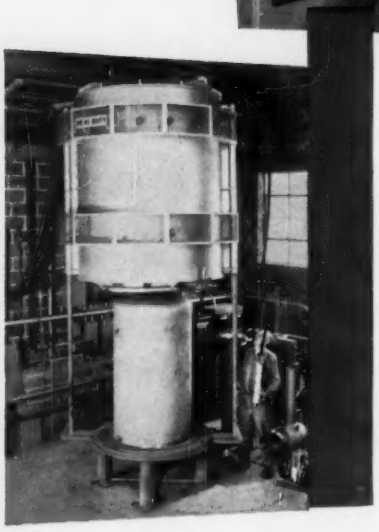
don't accept substitutes

FAMOUS CORNELL FLUXES
Trade Mark Registered

The* CLEVELAND FLUX *Company
1026-40 MAIN AVENUE, N.W. • CLEVELAND 13, OHIO
Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918

Circle No. 127, Pages 143-144





Light industrial furnaces...

Heat treating furnaces, fuel-fired and electric...

Non-ferrous metal melting furnaces, fuel-fired and electric...

Industrial ovens, fuel-fired and electric...

AND NOW

induction melting furnaces....

A full line of sizes and types for steel, cast iron, aluminum, copper, magnesium, silver and their alloys. Designed by a leading European producer of induction melting equipment and proven in hundreds of installations throughout the world. Get the full details from your Hevi-Duty sales engineer or

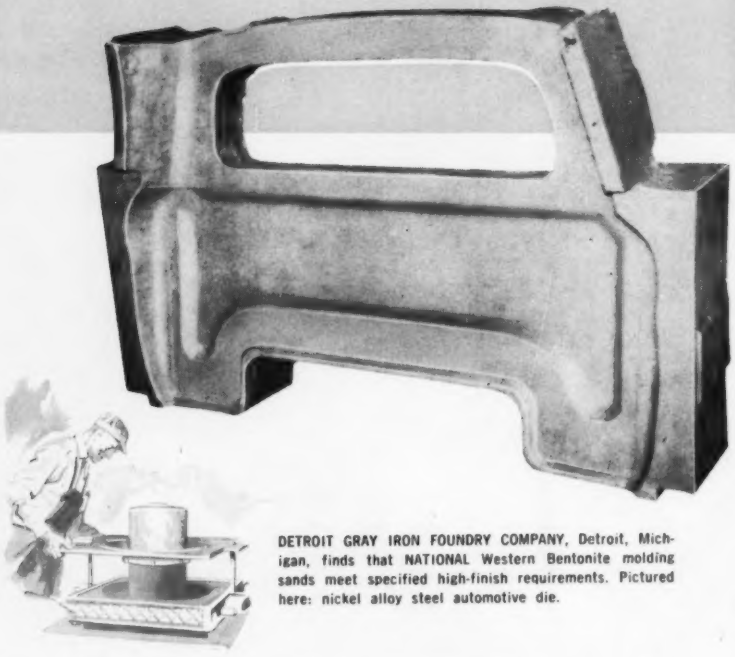
from Hevi-Duty

Circle No. 126, Pages 143-144

HEVI-DUTY
Electric and Fuel Fired
Industrial Furnaces and Ovens
B P C
A Division of
Basic Products
Corporation
Hevi-Duty Electric Company, Watertown, Wisconsin

for high-finish requirements

NATIONAL* Western Bentonite



DETROIT GRAY IRON FOUNDRY COMPANY, Detroit, Michigan, finds that NATIONAL Western Bentonite molding sands meet specified high-finish requirements. Pictured here: nickel alloy steel automotive die.

Detroit Gray Iron Foundry Company, Detroit, Michigan, uses NATIONAL Western Bentonite as the sand-bonding agent for a wide variety of castings. Detroit has found that the results are rewarding . . . smoother surfaces, closer tolerances, more faithful reproduction of patterns.

NATIONAL Western Bentonite in molding sands produces fine finish castings of all metals — malleable iron, gray iron, steel, brass, aluminum or magnesium.

For good molding, better cores and high-refractory core wash formations, use NATIONAL Western Bentonite. NATIONAL cores dry faster, have higher dry strength and contain less gas.

NATIONAL Western Bentonite is available from foundry dealers everywhere. See opposite page for list of dealers.

BAROID

BAROID CHEMICALS, INC.

*Registered Trademark, National Lead Company

6072

Circle No. 129, Pages 143-144

Reader Opinions . . .

Continued from page 11

in the U.S. Naval Academy asking for some information on sand cast bronze and stating that the Naval Academy library does not receive your publication.

In view of the fact that service academy graduates frequently become intimately involved in the design of military weapons systems, would it not be a worthwhile investment to expose all future officers to MODERN CASTINGS by placing the three service academy libraries on your mailing list? If only a few such embryo designers read the magazine, it might benefit both the defenses of our nation and the foundry industry in the future.

T. W. TEATOR
Golden Foundry Co.
Columbus, Ind.

Editor's Note: Good idea, Tom. We have followed your suggestion and added the service academy libraries to our MODERN CASTINGS *circulation.*

ARTICLE ENDS SEARCH

I am working in an analytical chemical laboratory under the research and development department. In our work we encounter a number of elements in the analysis of steel. The methods are complicated. A procedure of analysis which determines most of the elements in steel is badly needed.

I didn't think that such a procedure existed but an article in the April, 1956, issue of MODERN CASTINGS proved me wrong. The article was "A 45-minute Analysis of Slag" by W. L. Unfried, Texas Electric Steel Casting Co.

You can see that I am four years late in utilizing this information. I would like to remedy this situation by obtaining three copies of this article. The procedures outlined certainly help facilitate our complex procedure.

JOHN T. STEPHENSEN
Thiokol Chemical Corp.
Brigham City, Utah

Editor's Note: The value of the article proves that basic information doesn't have a date line.

FOURTH T&RI STUDENT

Please enroll our purchasing agent, W. A. Crede in the AFS-Training & Research Institute course, Purchasing of Foundry Materials.

Our records of T&RI enrollees shows that Mr. Crede is the fourth from our company. We plan to enroll at least

three more this year. It certainly is a wonderful program, well operated, and I can give it my unrestrained indorsement and appreciation. There is simply no substitute for this program in its advantages and benfits for smaller foundries.

ROGER W. GRISWOLD
Erie Malleable Iron Co.
Erie, Pa.

BRASS, BRONZE COMEBACK

I have very much enjoyed the article "Brass and Bronze Industry Fights Back" in the September issue of MODERN CASTINGS.

Would it be possible to get a dozen copies of this article?

FRANK S. RYAN
Saint Paul Brass Foundry Co.
St. Paul, Minn.

Editor's Note: A dozen copies are on the way.

VENTILATE WITH DEGASSER

We would like your assistance in determining the nature, amount and maximum allowable concentration of gas in the foundry atmosphere when aluminum melts with a proprietary compound.

The chemical additive is used to remove hydrogen dissolved in the aluminum melts. It is plunged to the bottom of the melt and allowed to decompose to a gaseous form which bubbles through the melt releasing and combining with the hydrogen, thus degassing the melt. A nucleant is also used for grain refining only. The procedure is identical.

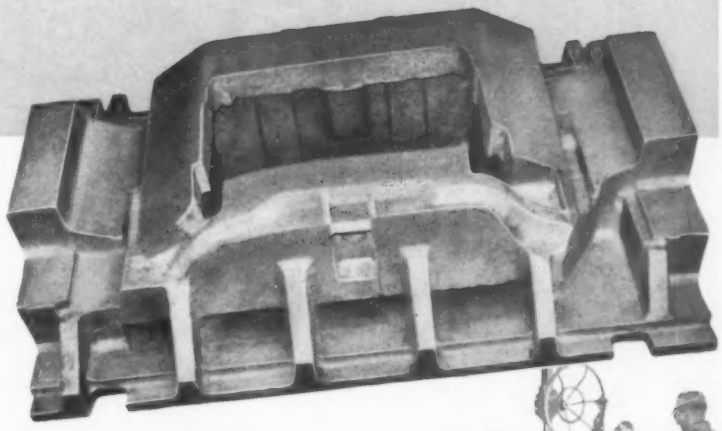
WALTER N. KNORR
Liberty Mutual
Brooklyn, N.Y.

Note: The degasser mentioned in your letter is hexachloroethane, also called carbon hexachloride. When subjected to high temperature it decomposes like other organic chlorides such as carbon tetrachloride. The decomposition products unite with hydrogen to form hydrogen chloride. In the presence of carbon monoxide, phosgene would be formed.

The maximal allowable concentration of hydrogen chlorine is five parts per million. That is not the danger limit but rather the threshold of irritation. The gas has sufficient warning properties so that no one could tolerate a concentration dangerous to life. The condition you refer to (in my opinion) is at worst a nuisance—not one injurious to health. Simple local ventilation

closer tolerances with

NATIONAL* Western Bentonite



DETROIT GRAY IRON FOUNDRY COMPANY, Detroit, Michigan, cast this 23,200 pound nickel alloy steel automotive die using NATIONAL Western Bentonite. Note the close tolerances and deep draw of this high-finish casting.

*Registered Trademark, National Lead Company

These dealers stock NATIONAL Western Bentonite

American Steel and Supply Company, Chicago, Illinois
Asbury Graphite Mills, Inc. Asbury, New Jersey
Asher-Moore Company, Richmond, Virginia
Brandt Equipment and Supply Company, Houston, Texas
George W. Bryant Core Sands, Inc., McConnellsville, New York
The Buckeye Products Company, Cincinnati, Ohio
Canadian Foundry Supplies & Equipment Ltd., Montreal 30, Quebec (Main Office)
Canadian Foundry Supplies & Equipment Ltd., Toronto 14, Ontario
Combined Supply & Equipment Company, Buffalo, New York
Foundries Materials Company, Coldwater, Michigan
Foundries Materials Company, Detroit, Michigan
Foundry Service Company, Birmingham, Alabama
General Refractories Company, Indianapolis, Indiana
The Hoffman Foundry Supply Co., Cleveland, Ohio
Independent Foundry Supply Company, Los Angeles, California
Industrial & Foundry Supply Company, Oakland, California
Interstate Supply and Equipment Co., Milwaukee, Wisconsin
Klein-Farris Company, Inc., Boston, Massachusetts
La Grande Industrial Supply Co., Portland, Oregon
Marthens Company, Moline, Illinois
Carl F. Miller and Company, Inc., Seattle, Washington
John P. Moninger, Elwood Park, Illinois
Pennsylvanian Foundry Supply & Sand Co., Philadelphia, Pennsylvania
Robbins and Bohr, Chattanooga, Tennessee
Smith-Sharpe Company, Minneapolis, Minnesota
Steelman Sales Company Munster, Indiana
Warner R. Thompson Company, Detroit, Michigan
Western Materials Company, Chicago, Illinois
Walter A. Zeis, Webster Groves, Missouri

Write today for BOOKLET giving further information on the benefits gained from using NATIONAL Western Bentonite

BAROID

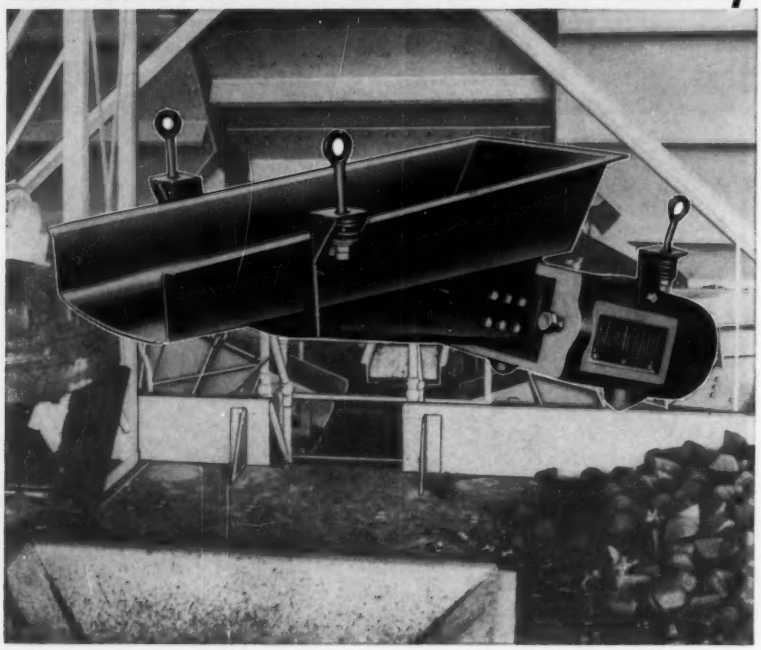
6073

BAROID CHEMICALS, INC.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
1809 SOUTH COAST LIFE BLDG., HOUSTON 2, TEXAS

Circle No. 129, Pages 143-144

SYNTRON cost-cutting equipment of proven dependable Quality

moves bulk material more efficiently



SYNTRON Vibra-Flow

VIBRATORY FEEDERS

—increase the operation efficiency of todays modern foundry, by more efficient, dependable material handling.

—By instant finger-tip flow control. The vibration of these feeders is instantly controllable providing a smooth, even flow of material to match operational capacities.

—By simplicity of design. Their powerful electromagnetic drive is designed to give long, dependable, trouble-free service with very little maintenance.

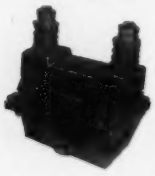
SYNTRON Vibratory Feeders are available in a wide range of sizes, tonnage capacities and trough styles to meet every need.

Write today for complete informative literature

SYNTRON COMPANY

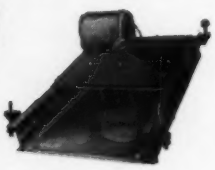
545 Lexington Ave. Homer City, Penna.

Other SYNTRON Equipment of proven dependable Quality



BIN VIBRATORS

VIBRATING CONVEYORS



VIBRATING SCREENS

Circle No. 130, Pages 143-144

would easily eliminate the nuisance. HERBERT J. WEBER, Director, AFS Safety, Hygiene, and Air Polution Control Program.

THANKS FOR PICTURES

We wish to extend our sincere thanks for the articles on quality control pertaining to castings submitted with your letter. We have found them to be interesting and helpful to us.

Your prompt response was appreciated.

R. C. COKER
The Martin Co.
Orlando, Fla.

CREATING NEW IDEAS

Ralph Betterley's "Teaching or Telling" and your statement regarding the nucleation of ideas, are sound teaching points to those concerned with creative communication in education and industry.

Telling about pattern designs already evolved, however ingenious they may be, is not so effective as systematic and unobtrusive questioning so as to evolve the design before the students. What is wanted is not pre-digested matter, but a mode of digestion.

A branch of mathematics called heuristic, aims at studying the methods and rules of discovery and invention. Prof. Polya's book, "How to Solve It" (Princeton University Press, 1944) is an excellent presentation of this subject. Its central feature is a chart of systematic questioning.

The use of this chart shows that the initial conception of a pattern design is largely analogical and that systematic questioning has far greater chances of bringing a large number of analogous cases in juxtaposition than telling about individual designs.

I suggest that Prof. Polya's chart be reprinted in a future issue of MODERN CASTINGS.

S. RAMAMURTHY
Indian Institute of Science
Bangalore, India

Note: Dr. S. Ramamurthy's letter is both interesting and challenging. We appreciate his complete recognition of the difference between "teaching and telling." His letter is a generous testimonial of the often overlooked value to be gained in teaching if students can be guided to think creatively toward the solution of problems. His application of heuristic procedures in the "teaching" of pattern design is scholarly and commendable. Let's have more of it in the industry. Prof. Polya's chart will be considered for future publication.—R. E. BETTERLEY, AFS Director of Education.

METALGRAMS

UNION CARBIDE METALS

. . . news about "Electromet" ferroalloys and metals

NOVEMBER, 1960

LOWER COSTS FOR STAINLESS STEEL -- Stainless foundrymen are making big savings by using ferromanganese-silicon for finishing additions of silicon and manganese. Assuming 100 per cent recovery, $2.86 per ton can be saved for a 1 per cent manganese and accompanying 0.45 per cent silicon addition. The alloys replaced are electrolytic manganese and ferrosilicon. Several foundries also report getting cleaner steel when using ferromanganese-silicon. Write for F-20,093 for further information.

* * *

EFFICIENT PRODUCTION OF HIGH-CARBON IRON -- A low-silicon pig iron contains more carbon than a high-silicon pig. Thus, low-silicon pig is widely used by iron foundries producing high-carbon cast iron for castings requiring excellent machinability and freedom from internal shrinkage defects. Additional silicon can be conveniently added to the cupola as "EM" silicon briquets. Ask your Union Carbide Metals representative about this economical practice. For briquet specifications, write for F-20,066.

* * *

BUILDING BIGGER MARKETS -- "Your man's practically a member of my staff," a president of a steel firm said of one of UCM's market development specialists. These men work with steel producers to develop new markets and expand old ones. Primarily, they promote the use of stainless steel and titanium (including castings) in transportation, architecture, process industries, and consumer goods. More details can be obtained by writing for the article, "Men, Metals, and Markets," in the Spring 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

SILICON IMPROVES ALUMINUM CASTINGS -- Almost all aluminum castings contain silicon. The element improves castability, allowing adequate filling of thin sections and complex shapes. It also lowers the coefficient of thermal expansion and reduces hot shortness and cracking. A choice of six grades of "Electromet" silicon metal are available for additions to aluminum casting alloys. For more silicon data plus how the auto industry uses silicon in castings, write for the article, "Aluminum Auto Castings Grow," in the Fall 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

AN EFFICIENT BLOCK -- Why is silicomanganese the most popular blocking alloy in the steel industry? The alloy dissolves rapidly, giving faster blocks and shorter blocking times. It allows higher recoveries and closer control of manganese and chromium added to the furnace. It also improves steel cleanliness. Silicomanganese also may be used for low-cost ladle additions. For further information, write for the article, "Silicomanganese Improves Blocking Performance," in the Fall 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

"Electromet," "EM," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

UNIVERSAL
REFRACTORY GATING COMPONENTS

• The *Thinwal* construction, providing as much as *35% lighter weight* will not spall nor erode in use even at temperatures up to 3250°F. They eliminate slag inclusions, stop rejects, reduce cleaning room time.

Standards and specifications bulletin available on request. Units for special applications quoted.

UNIVERSAL
CLAY PRODUCTS CO.

1505 First St. • MAin 6-4912 • Sandusky, Ohio

Circle No. 131, Pages 143-144

DIETRICH'S CORNER

Is Organized Recreation Necessary?

by H. F. DIETRICH

Any trained personnel counselor will admit that employee recreation is a management problem, but there, agreement ends. Because of difference in size, location, and general policy, each company has a separate problem. According to his own experience, each counselor has his own idea about how the program should be carried out.

Just as man cannot live on bread alone, he can't live on work alone. Left to his own devices, a workman will find some diversion from his routine worklife. In the old days—when I rolled my molding tools in an apron—we found our own diversion without company guidance. Back of the old National Brake foundry was a rail siding called the Sports Arena. Because rolling dice and fighting in the shop were the cause of instant dismissal, the boys would retire to the Sports Arena any time there was a difference of opinion. There they could always find an empty box car in which to settle their differences. A good fight in the close confines of a box car in the Sports Arena often became an audience participation sport.

Finishing a dice game after dark became an adventure. A contestant would roll the dice, then someone would light a match to see the result. With every roll covered at least six ways, the dice bounced against a grain door, and the the floor sprinkled with wheat, it was practically impossible to set up a rigged game.

The idea of employer sponsored recreation isn't new. As an example, we have those lavish affairs thrown by the Caesars for their civil service yes-men. The attendance was remarkable. Of course, the employees had a choice. They could attend either as guests, or as hors d'oeuvres on the menu of hungry lions. It was a simple matter to terminate employment by inviting a recalcitrant employee to join the floor show. I understand that "Ladies' days" at these affairs were something to write home about. Wives—however remote from the employer—have always exerted remarkable influence on employee relationship.

With time, there has been a change not only in the preference in recreation, but also in the reason for throwing a party. The reason for employer sponsored recreation is two-fold. First, the altruistic desire to relieve the tensions created by our mechanized jungles; and second, to develop company goodwill which we hope will generate cooperative production. Unlike many other products, goodwill lends itself best to the soft sell routine. Caesar's shindigs—although they were family participation affairs—could have been construed as coercive because of hard sell methods.

Any sponsored program which occurs at regular intervals will assume the characteristics of an institution if continued over a long period of time. Employees will begin to believe that such affairs are their due just for punching the clock. Unless each event is bigger and better than the last, the comparison is detrimental to goodwill. Perhaps that is how Caesar got into trouble. After 50 gladiator duels to the death, and feeding 100 slaves to the lions, what else is there? Even the lions got fed up with the entertainment.

Man is a strange animal. He will accept anything he can get for nothing, but he will resent any mention of the fact that he has done little to earn what he gets. Any obvious intrusion of an employer into a recreation program—however altruistic—will be viewed with suspicion. With tastes varying from the primitive fights of the aborigines to the night at the opera of the eggheads, the problem seems to be finding some channel of recreation that is acceptable to everyone employed in a single industry.

In conclusion we might say that employer-sponsored recreation is vital to company interest, but it must be handled with extreme caution to avoid suspicion of coercion. Actual participation of management is best at a minimum, and no matter what you do, you can't please everyone.

Circle No. 132, Pages 143-144 ⟶

NOW MORE PROFITABLE COREMAKING...with

CHEM-REZ* A-200

Completely self-curing foundry resin that "BAKES" AT ROOM TEMPERATURE

FACT: YOU CANNOT OVERBAKE A CHEM-REZ A-200 CORE

CHEM-REZ PROFITMAKER #1

Resulting from NO-BAKING:

- ☐ Convert oven space into useful coremaking space.
- ☐ Eliminate handling cores in and out of ovens.
- ☐ Run emergency jobs in one day. Relieve scheduling of work. Reduce time between core fabrication and casting.
- ☐ Eliminate core scrap due to baking.

See how CHEM-REZ A-200 can change COREMAKING TO PROFITMAKING

Here are some profitable ideas which can be employed through the use of CHEM-REZ A-200. Why not check the ideas which will increase profit in your foundry? Then call your ADM-MAN for a demonstration.

CHEM-REZ PROFITMAKER #2

Resulting from RELIABLE, COMPLETE CURING BY CHEMICAL REACTION:

- ☐ Reduce scrap cores caused by insufficient cured strength.
- ☐ Increase rate of turnover of active core boxes.
- ☐ Eliminate compressed air for curing. (Air accelerates cure only by helping remove the water formed by the resin reaction.)
- ☐ Convert storage space required for rammed up cores "waiting in line" for oven room into useful coremaking space.

CHEM-REZ PROFITMAKER #3

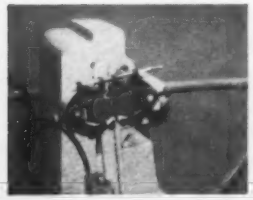
Resulting from HARD SURFACE CORES:

- ☐ Paste core assemblies and/or apply mold washes immediately upon drawing core from box.

*In Canada, manufactured and sold under the trade-name LIN-O-SET A-200.

CHEM-REZ PROFITMAKER #4

Resulting from HIGH TENSILE STRENGTH:



- ☐ Reduce, in part, the use of rods and wires.
- ☐ Save roll over; draw core from box, not box from core.
- ☐ Use adaptable CHEM-REZ A-200 for dry sand mold facing applications with any fairly dry heap sand as back up.

Archer QUALITY

WRITE (on your company letterhead) FOR TECHNICAL BULLETIN

Archer-Daniels-Midland company

FEDERAL FOUNDRY SUPPLY DIVISION • 2191 West 110TH Street • Cleveland 2, Ohio

MARSCHKE

The undisputed champion in any grinder division. Precision built, with variable speed, to provide maximum wheel life and metal removal. A maintenance man's favorite for long, trouble-free service. Write for Bulletin No. 108.

MARSCHKE

The finest heavy duty swingframe grinder on the market today. Built to withstand plenty of abuse, affords extreme maneuverability, dependable as the Rock of Gibraltar. Write for Bulletin No. 112.

MARSCHKE

FOR YOUR FILES:

Bulletin #108 contains complete specifications on the famous Marschke (Marsh-key) line of heavy duty, hard-wheel, floor snagging grinders.

Bulletin #112 covers Marschke light-weight, heavy duty and direct drive swingframe grinders, swing cut-off and Marschke buffers. All we can say is: You **ought** to have this information!

Bulletin #110 contains complete information on the famous G & P Heavy Duty and XTRA Heavy Duty swingframe abrasive belt grinders, of especial interest if **fast** metal removal is your problem.

FREE: WRITE FOR 'EM TODAY

Grinding and Polishing Machinery Corp.
SUCCESSORS TO VONNEGUT MOULDER CORPORATION

2530-C Winthrop, Indianapolis 5, Ind.
Circle No. 133, Pages 143-144

Select the Right Course

by RALPH BETTERLEY

In the September issue of MODERN CASTINGS (see page 25) ten points were discussed and proposed as important considerations if industry is to realize maximum return on its investment in out-of-plant training courses. Because of lack of space, it was pointed out that some of these points would be expanded in future issues. In the October issue this column discussed No. 5 *Select the Right Men*. Equally important, however, and one which must be considered simultaneously is: No. 3 *Select the Right Course*.....

In discussing this point, it should be emphasized that the *right* courses cannot be selected without carefully considering all points proposed at the outset. Outside training courses should be selected in terms of the specific needs of the foundry personnel involved and the peculiarities of the plant concerned. Intensive out-of-plant courses can be effective in personnel development and, on a broader scale, in the over-all organizational development within a plant, if care is used in selecting courses.

Short specialized courses can in many instances be utilized to supplement other training programs. These programs may develop from internal change within the organizaiion such as: new equipment, new products and markets, new processes, personnel changes, modernization of physical plant and research and development projects. If training is necessary to efficiently bring about change in the areas mentioned above, it becomes increasing important that the correct courses should be selected to achieve these objectives.

It should not be overlooked also, that, if the right courses are selected for the right key personnel, the "students" in turn are motivated towards self-improvement after "going to school." The value is multiplied if the instruction given is carried over to additional personnel working in the area where the course applies. Thus, maximum benefits can be achieved.

Many so-called progressive companies have in some cases haphazardly selected "outside" training programs for the registrants. This is particularly true in the management field where such executive courses have tended to become a fad. In many instances these "high-level" programs are expensive and top management has hastily registered people on the sole justification that they want their plant to be "up-to-date." Without sufficient forethought on the goals to be achieved by specific training courses, serious disappointments can result.

I have no argument with these high-level management programs, or operational basic courses, for that matter. Successful training-minded companies should and are making valuable use of these training opportunities. I do say, however, that the training directors and/or top management, making these decisions should carefully consider the course, the participant and the *application* in terms of the organization's over-all development and objectives if value is to be received. If the plant has a training director this should be one of his important responsibilities.

In the Journal of the American Society of Training Directors August 1960, Neeley D. Gardner, indicates that as training directors, "we should aim for organization development as well as management and employee development." To accomplish employee development he further states: "In most individual development, we take a look at what we believe to be the job that the person will be required to do, we evaluate the individual in terms of personal abilities, accomplishment, and potential; we evaluate performance in the light of objectives and we prepare plans for improving such performance."

Foundries are not excluded from the responsibility of wisely selecting out-of-plant courses for their personnel. By careful study and forethought the *right* courses for *their* particular needs can give *more mileage from the training dollar.*

"INGREDIENTS" MAKE THE DIFFERENCE

REVIVO — the right recipe for easy sand control

The recipe for fire clay was written by Mother Nature. The ingredients are a naturally occurring blend of clay and silica. The proportion can range from 30% to 80% clay in the fire clay or refractory you buy. It all depends upon the effect of nature's elements during the last 100,000 years . . . of weather, wind and water.

Revivo gives you better results per dollar. That's because Revivo's uniformly high purity is recognized by all types of foundries . . . means easy sand control, better castings. Actually, there's no finer kaolinite. The typical Revivo as used by all types of foundries during the last 37 years is as follows:

Kaolinite (Al_2O_3. $2SiO_2$. $2H_2O$)	83.1%
Quartz (SiO_2)	10.7%
Rutile plus Leucoxene (TiO_2 plus TiO_3. nH_2O)	2.7%
Muscovite mica (K_2O. $3Al_2O_3$. $6SiO_2$. $2H_2O$)	1.8%
Iron pyrite (FeS_2)	0.1%
Limonite (Fe_2O_3, nH_2O)	0.4%
Ilmenite (FeO. TiO_2)	1.2%

Write or call your IMC full-line service engineer for more Revivo details and for an unbiased bond clay recommendation.

EASTERN CLAY PRODUCTS

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

ADMINISTRATIVE CENTER, OLD ORCHARD ROAD, SKOKIE, ILLINOIS, YORKTOWN 6-3000

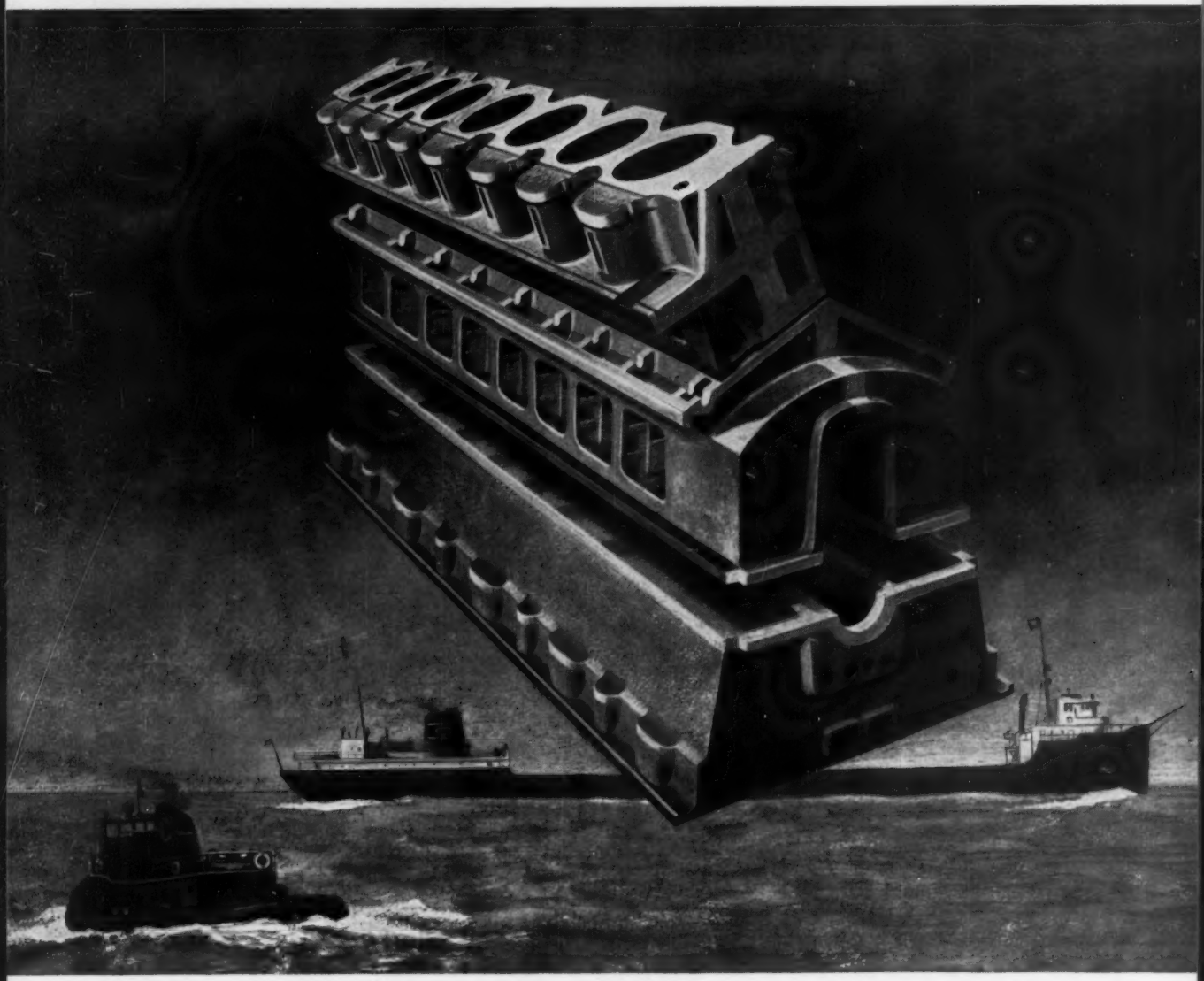
IMC

PRODUCTS FOR GROWTH®

®TRADEMARK

Circle No. 134, Pages 143-144

How the Foundry Industry Serves America . . . #5 of a Series



5 REASONS WHY IRON CASTING IS SPECIFIED FOR 7700-H.P. DIESEL CRANKCASE

Fabrication of steel was first specified for this 35,000-lb. crankcase of a 7700-hp. marine diesel engine. But, after careful study, the obvious advantages of gray iron dictated the final choice of a gray iron casting.

The excellent vibration damping characteristics of gray iron assure the lowest possible noise level. The rigidity and mass which is easily designed into a casting contributes to permanent alignment. Gray iron gives good engine heat distribution. The inherent stability of gray iron eliminates need for stress relieving. And because of the large amount of drilling and tapping required, the easy machinability of gray iron is an important advantage. All of these qualities were taken into consideration before the specifications were changed from steel weldment to gray iron casting.

For the production of structurally sound iron castings, Hanna Furnace provides foundries with all regular grades of pig iron . . . foundry, malleable, Bessemer, intermediate low phosphorus, as well as HANNA-TITE® and Hanna Silvery.

Facts from files of Gray Iron Founders' Society, Inc.

HANNA
BEST KNOWN NAME IN IRON

THE HANNA FURNACE CORPORATION
Buffalo • Detroit • New York • Philadelphia

Hanna Furnace is a division of **NATIONAL STEEL CORPORATION**

Circle No. 135, Pages 143-14

In the interest of the American foundry industry, this ad (see opposite page) will also appear in

STEEL
IRON AGE
FOUNDRY
AMERICAN METAL MARKET

How the Foundry Industry Serves America . . . 42 of a Series
5 REASONS WHY IRON CASTING IS SPECIFIED FOR 7700-H.P. DIESEL CRANKCASE
YOUR NAME HERE

FREE!

REPRINTS OF THIS AD WITH YOUR FIRM'S SIGNATURE

If you would like to have reprints of this ad to mail to your customers and prospects, let us know. Reprints will have no Hanna product message or signature, but will be imprinted with your firm name and address. Absolutely no obligation. To order your reprints, fill in and mail the coupon below.

The Hanna Furnace Corporation
Detroit 29, Michigan

Please send me_____ reprints of Ad No. (No.)
____ of your Foundry Industry Series.
Imprint as follows:

_____
_____
_____

Send reprints to:

NAME_____

I understand there is no charge for this service.

Circle No. 135, Pages 143-144

Din! Din! Din!

by HERBERT J. WEBER

The dissatisfied car owner referring to his "lemon" said, "Every part on it except the horn makes noise—it's driving me crazy."

The mechanic, working on a diesel engine for several hours, may regard the loud exhaust of the engine when it starts as pleasant. A passerby may consider the noise objectionable.

Thus, noise may be defined as unwanted sound. The effects of noise on man are said to be manyfold. Air raids over England during World War II were followed by a large increase in patients admitted to hospitals for treatment of peptic ulcers, goiters, and other disorders associated with the nervous system.

Noises in military tanks and high-speed planes, the roar of artillery fire often impair hearing and induce ringing in the ears and dizziness. Violent explosions may not only rupture the eardrum but may also result in shell shock.

Many industrial noises reduce the efficiency of workers; interfere with easy and accurate speech communication; cause impaired hearing; and contribute to irritability, nervousness and probably to absenteeism and labor turnover. Maybe when you gave that order that was not correctly carried out, the workman failed to hear it accurately.

The harmful effects of noise on the production of industrial workers are often difficult to evaluate. However, there is considerable evidence that the reduction of noise in industrial plants results in an increase in employee output. Often it's sufficient of itself to justify the cost of noise reduction.

Sudden, intense noises make us jump; quicken our pulse; raise our blood pressure; contract our stomach muscles, and probably contribute to fatigue and various neuroses.

The harmful effects of noise on the nervous system may not have been conclusively demonstrated. Many claims of injury are based on speculation or even sheer supposition rather than facts. Still, there is plenty of evidence that long exposure to loud noises or a single exposure to a sufficiently intense noise can cause hearing impairment.

Of course, not all noise is industrial in origin. If you ride the New York subway, for example, you are exposed to a noise level of 103 decibels (db). A valve-type toilet makes a noise of 88 db. Whereas a pneumatic ram makes a noise of 90 db.

Animals exposed to a noise of about 130 db show destruction of parts of the organ of hearing.

In man, noises in excess of 160 db are beyond the anatomical safety factors of the ear and cause *immediate* harm. Sound levels of 120 db produce discomfort; 130 db, a tickling sensation; and 140 db, pain.

Many persons can adjust themselves to noise so that it has little measurable effect on the speed and accuracy of their work. However, we do not know what effect the process of adjustment has on their nervous system.

There are individual differences in people. Some are "allergic" to noise which may be the final element, coupled with others, that precipitates the nervous breakdown or crackup. This phenomenon may be called a synergistic effect.

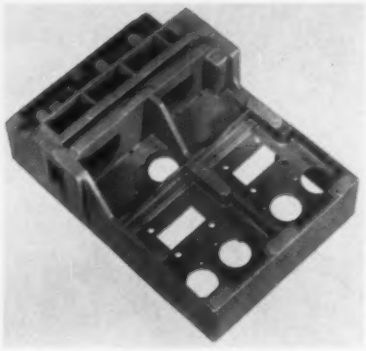
In other words, no single element may produce the breakdown, but all elements, when combined, bring about the crackup.

When the physician prescribes quiet surroundings for the patient, he is usually giving good advice. There is substantial evidence that noise can and does drive people crazy. I believe it has been reported that test animals subject to intense noises, develop changes in character and habits.

Maybe our disgruntled motorist who bought that noisy auto was right. Maybe it was in fact driving him crazy.

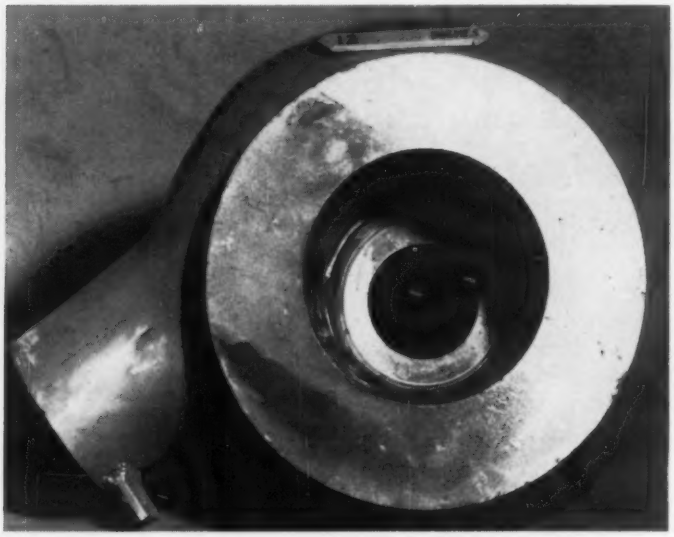
Here's How . . .

Each month this department brings you the newest developments in the foundry industry. These represent, in the opinion of the editors, ideas and applications which may help you perform a better job.



. . . a fork-lift truck can fit into your employee recreation program. A regulation basket-ball backboard with sleeves that fit over the forks provides amusement and exercise in the parking lot during lunch time. Might come in handy around the swimming pool.

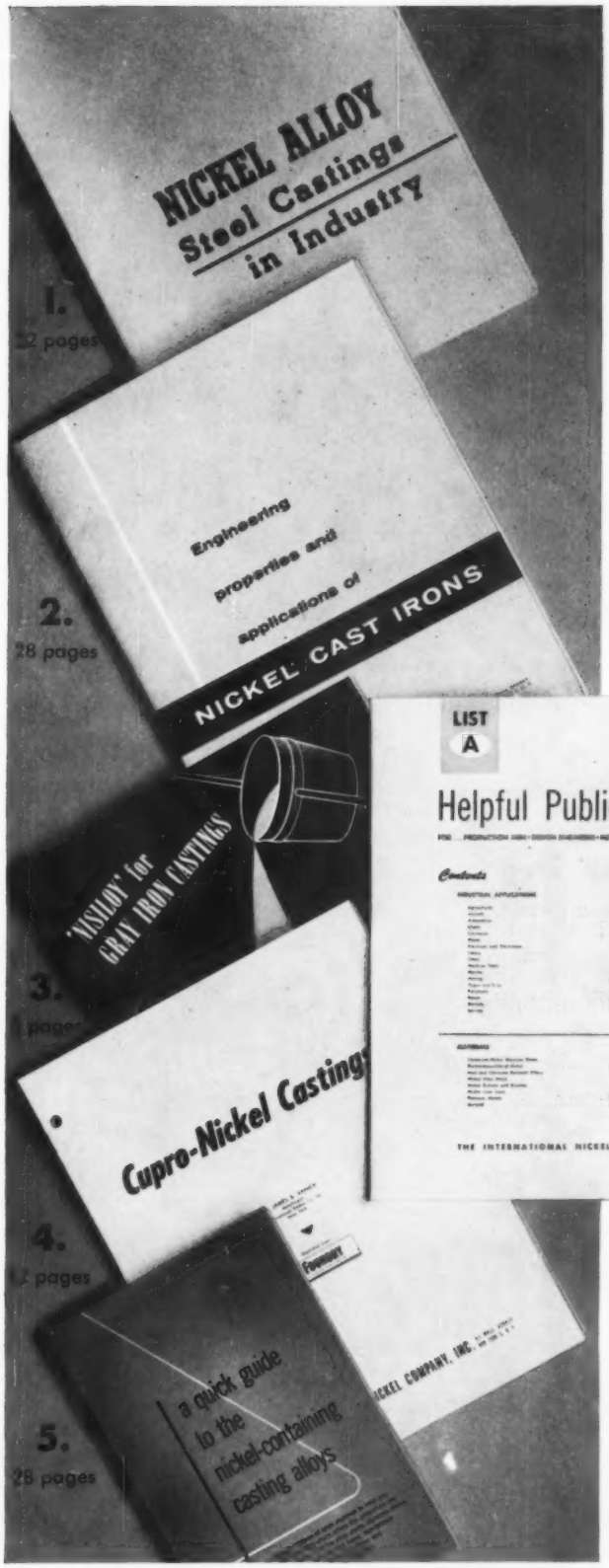
. . . investment casting by the ceramic shell process saved two man-months of machining formerly required to fabricate this missile housing unit. All recesses, holes, slots, and critical dimensions can be cast into the part which is made by Arwood Corp.



. . . America's first atomic-powered merchant ship, the N.S. Savannah, uses stainless steel castings in the nuclear power plant. Four of these volute casings, weighing 3150 pounds each, are vital parts of the primary coolant pumps which can circulate 5000 gallons per minute of pressurized water through the reactor and heat exchangers.

. . . to simplify mold weighting operation. At Wolverine Brass Works, Grand Rapids, Mich., green sand molds travel down roller conveyor from molding station. They pass under a steel beam from which mold weights are suspended. Each weight is attached to a handle which lowers weight onto mold and clamps it firmly in position. After pouring the handle is pulled forward, raising weight off mold. Molds then roll to shakeout screen.

Continued on page 27



Which of these 6 valuable Inco publications can help you?

There is probably more information about Nickel in Inco publications than in all the encyclopedias and text books of the world.

This material has been accumulated gradually through the 40 years that Inco has carried on its extensive Research and Development program.

Notice the six pieces of literature shown at the left. Five of them deal specifically with your interest—the production or utilization of quality castings by industry. All five contain helpful technical data presented in an easy-to-read style.

And the sixth? It includes a detailed listing of the many more publications available to you—plus a handy postage-paid request form for the literature of your choice. Just mail the coupon below for any of the publications you'd like to have.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

6. 22 pages

FREE! MAIL THIS COUPON TODAY

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

Without obligation, please send me the publications I have circled: 1 2 3 4 5 6

Name _____ Title _____

Company _____

Address _____

City _____ Zone ____ State _____

(GA-7031)

INCO NICKEL

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

ALU melt

*ALUmelt crucibles offer:

Faster melting time

Better service life

Least contamination

Up to 35% savings on initial investment

Crucibles for melting and holding aluminum

More capacity

Easier cleaning

*as reported by user foundries

Send for our new Alumelt brochure . . . completely details the advantages of Alumelt for you.

VESUVIUS CRUCIBLE CO., P.O. Box 8275, Pgh. 18, Pa.
Send Alumelt brochure to:

Name.....

Firm Name.....

Firm Address.....

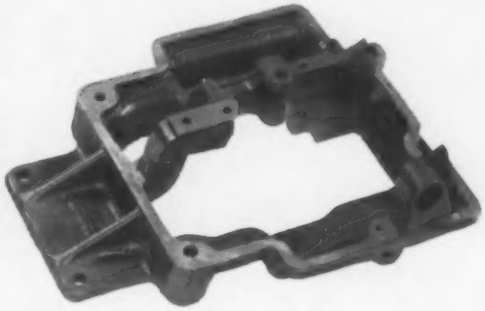
City..... Zone..... State.....

CONCEIVED AND DEVELOPED BY
VESUVIUS CRUCIBLE CO.
FOR THE METAL POURING INDUSTRY
SWISSVALE • PITTSBURGH 18, PA.

Here's How . . . *Continued from page 24*

. . . A three-piece permanent mold opens to reveal a 24-pound automatic transmission casing cast at the Ford foundry in Sheffield, Ala. This is one of largest aluminum parts now being used in the automotive industry. Designing this equipment and dies shows Ford Motor Co.'s casting ingenuity.

. . . switching to malleable iron castings saved $21,000 for a manufacturer of heavy duty automobile jacks. Although this savings was effected on 4000 units, a cost breakdown showed that the change was more economical in malleable for any quantity above 200. Largest of the parts is the 16-inch swivel caster bar (bottom). The previous fabrication required six machine operations—punching, shearing, sawing, chipping, grinding, and reaming—followed by joining at eight points. Cost of this assembly was $3.70 whereas the redesigned malleable unit had a $1.02 price tag.



. . . Decatur Casting Co., Decatur, Ind., meets the demands for top quality gray iron castings. This 3½ pound bracket, used on a gasoline pump, has many sections only ¼ and 3/16 inches thick. After drilling and tapping holes there often remains only 1/16 inch wall thickness. Any porosity, cracking, or warping in this casting would make it a total loss.

THE OPEN DOOR TO
GREATER FOUNDRY PROFITS CCC*

By using— Interlake's famous Meltrite pig iron + steel + your own returns, you are sure of a **known** analysis in the charge.

The results: (1) Shippable castings at lower cost.
(2) Greater customer satisfaction.

Remember—**Meltrite is always in dependable supply.**

*Controlled Cupola Charge. Wherever you are a PM & Company metallurgist is ready to discuss this with you.

P M

PICKANDS MATHER & CO. Cleveland 14, Ohio

Chicago • Cincinnati • Detroit • Duluth • Erie • Greensboro • Indianapolis
New York • Pittsburgh • St. Louis • Washington

IRON ORE • PIG IRON • COAL • COKE • FERROALLOYS • LAKE FUELING • LAKE SHIPPING

Circle No. 138, Pages 143-144

7 Ways to Solve Steel Castings' Slow Growth Problem

New survey by MODERN CASTINGS *points up how steelcasters can improve their competitive position, make more sales and more money. Editor Jack Schaum finds many key executives are sparking positive programs to better the industry.*

The Problem . . . The steel casting industry is not growing at a rate sufficient to keep pace with the rest of the nation's industry. Here's what some leading foundry executives say about this:

1. We are continually losing markets to other fabricating processes, metals, and materials.

2. Too many foundrymen take a part designed as a forging, weldment, or fabrication and try to pour it. This invariably leads to inferior castings which erode confidence in future use of steel castings for any application.

3. Too much nonsense in pricing castings by the pound.

4. Too long a lag between the attainment of applied research results and their application in foundry production.

Why There's a Problem . . . Under pressure of war-time economy steel foundries expanded to a productive capacity almost double that needed in peace-time. Now they are scrambling to find new markets that will put this capacity to work. This situation is magnified because steel foundries require greater capital investment than do foundries melting other metals.

Steel foundries must have high priced tools and materials to work with: electric arc and induction furnaces, heat-treating furnaces, welding equipment, x-ray and magnetic particle inspection devices, super-duty refractories, high temperature molding materials, and expensive alloys. This makes over-capacity an expensive luxury.

The high rate of technological obsolescence compounds the already heavy burden of expensive equipment. Steel foundries have to stay modern to remain competitive

Too many foundrymen take a part designed as a forging, weldment, or fabrication and try to pour it. This invariably leads to inferior castings which erode confidence in future use of steel castings for any application.—Don Rosenblatt

The technological advances being made in the universities and foundry laboratories to give better understanding to the physics of solidification, heat and mass flow during solidification, thermodynamics and kinetics of melting and refining, and the application of these principles to practice are the teachings that the steel foundry industry must follow for the greatest advancement.—A. J. Kiesler

Growth in use of steel castings exists in a wider penetration of presently known and proven uses. The saturation of these fields constitutes the highest possible volume.—E. J. Wellauer

today. Progress is particulary rapid in modern casting technology.

Greater skills and more technical personnel are needed to operate the highly complex steel foundries of today. With all this direct and indirect overhead, it's not too hard to appreciate why steelcasters are constantly fighting the cost-bulge. They must have well planned equipment amortization funds to re-invest in modernization, or go out of business.

The Challenge . . . Today, as never before, many industries are turning to the steelcaster. Design engineers need metals that meet the ultimate in physical properties. Steel castings with tensile strengths as high as 300,000 pounds per square inch and 30 per cent smaller are being made for aerospace industries. This example demonstrates the position of technological leadership the steel casting industry faces.

What Can Be Done . . . MODERN CASTING's survey revealed that the steel casting industry can improve if it:

1. Educates customers to produce more economical design with optimum castability and maximum strength with minimum weight. Put the metal where high stresses require it, and take it away from low stress areas.

2. Conducts an aggressive marketing program that overcomes basic prejudices against castings. Reach all purchasing, engineering, and production personnel in every industry that holds a possible use for steel castings. Include advertising in this program.

3. Produces reliable high integrity castings by building quality into every operation—molding, gating, risering, melting, and pouring. Uses a statistical quality control

program to keep every operation on target so casting quality is continuously reproducible.

4. Improves communications with design engineer by providing an easily digestible, truly realistic understanding of both the potentialities and limitations of cast steel as a competitive material of construction.

5. Trains steel casting salesmen to use aggressive hard-sell tactics, imagination and persistence in converting parts over to castings. Selling must be done intelligently with price based on complexity of the job, not on the casting weight.

6. Reduces cost of the finished product by casting closer to size to minimize machining. Produce acceptable surfaces to reduce expensive cleaning and repairing operations.

7. Maintains aggressive research and development programs at the plant level and in technical organizations, such as the American Foundrymen's Society and the Steel Founders Society of America.

New Applications . . . Technological breakthroughs and product and process innovations are leading the way to new market opportunities for steelcasters. MODERN CASTINGS lists a few uncovered by its probe of steel casting opportunities.

1. Construction equipment (on or off-highway); chemical processing equipment; auxiliary machinery indirectly used in ordnance, missile and other defense programs; steel mill maintenance equipment; aircraft; turbines; machine tools; mining; and railroads—all are industrial areas offering new opportunities for castings applications.

2. Castings for the fast growing truck industry.

3. Valves and cylinders for automated equipment.

4. Equipment to convert saline water to fresh water—a new industry destined to grow and need more steel castings.

5. Load carrying members of ground support equipment for guided missiles.

6. Castings for highway bridges.

7. Centrifugally cast tubular parts.

8. Heat resistant steel castings for petroleum and chemical industries.

9. Corrosion resistant steel castings for chemical and food process industries.

10. High integrity, complex shape, high strength-to-weight ratio, missile components which can withstand forces in any direction.

11. Combinations of castings and rolled shapes welded together into one complex integral unit.

Conversions and re-design of parts to castings is a two-way street. The competition is working hard—and got off to an earlier start—to convert cast components over to stampings, weldments, forgings, plastics, etc.

This is a clear indication that new applications are being born every day in an industrial world where invention, mass production, and competition set a gruelling pace. Walk through any manufacturing plant in the country and you can see parts which can be converted to the casting. This is where the sales engineer comes in!

New Tasks for Sales Engineers . . . According to Paul Bergmann, today's casting salesman must be a combination engineer, metallurgist, foundryman coordinator and opportunist. He must keep abreast of

We are encouraged by the growing use of cast steel components in atomic energy equipment—equipment which is destined to replace conventional fuel burning equipment in all fields. Needed are high stressed castings capable of functioning at both elevated and sub-zero temperatures. It is a field in which high alloy steels are cast to shape and heat treated to tensile strengths of 200,000-300,000 pounds per square inch.—Dale L. Hall

Steel castings in ballistic missiles and in their launching gear is dramatic evidence of what can be done by combining the excellent economical strength-weight properties of steel with weight conscious design.—I. M. Emery

THE CONTRIBUTORS

Joe W. Beckham
Research & Design Supt.
Texas Foundries, Inc.
Lufkin, Texas

Paul Bergmann, Vice Pres., Sales
Westlectric Castings, Inc.
Los Angeles, Calif.

William A. Dunn, Jr.
General Sales Manager
West Michigan Steel Foundry Co.
Muskegon, Mich.

I. M. Emery
President & Gen. Manager
Massillon Steel Casting Co.
Massillon, Ohio

R. L. Gilmore
President
Superior Steel & Malleable
Castings Co.
Benton Harbor, Mich.

Dale L. Hall
Works Manager
Oklahoma Steel Castings Co.
Tulsa, Okla.

A. J. Kiesler
Metallurgy and Ceramics
Research Department
General Electric Co.
Schenectady, N. Y.

W. W. McCullough, Sales Mgr.
Special Products Division
American Cast Iron Pipe Co.
Birmingham, Ala.

Don Rosenblatt
Chief Metallurgist
American Foundry & Machine Co.
Salt Lake City, Utah

Paul H. Stuff
President
Ross-Meehan Foundries
Chattanooga, Tenn.

E. J. Wellauer
Director, Research & Development
The Falk Corp.
Milwaukee, Wis.

John Zotos
Assistant Professor
Northeastern University
Boston, Mass.

Robert L. Zwald
Asst. to General Sales Mgr.
Electric Steel Foundry Co.
Portland, Ore.

engineering changes by customers and work closely with design engineer by suggesting materials and designs to suit foundry practices and economics.

He must be alert for opportunities to suggest or recommend conversions to castings and watch for new accounts, new contacts, and new products. He should understand his customers' end product, the equipment used to produce it, and the market to be reached.

Finally, the salesman must coordinate his activities with his works manager, foundry superintendent, metallurgist, and others able to assist himself and customer.

Something New: Value Analysis . . . A new influence is fast entering the manufacturing picture. It's called Value Analysis—an organized program to seek the lowest price that must be paid to accomplish a function. Purchasing becomes a full-time partner in cost reduction with engineering, manufacturing, and vendors. Casting salesmen find the welcome mat out and doors open for them to consult with the buying teams on cost reduction at improved quality and performance.

Trained value analysis engineers follow a step-by-step procedure to scrutinize every part and every operation in the manufacture of a product. Value analysis teams are critically surveying a multitude of fabricated parts. As a result a broad new market of casting opportunities is being born. This could mean a lot more business if your sales engineers do a good job of customer education.

Technology Is Creating Markets . . . The tempo of today's technology manages to keep every foundryman several laps behind the latest developments. In fact there has become a serious lag in the practical application of practices firmly established through research.

For example, very few foundries have applied the technologies of vacuum and inert atmosphere melting, casting, and processing. Likewise, improved refining techniques for optimum removal of detrimental elements like phosphorous and sulphur are available but not too widely applied.

A. J. Kiesler emphasizes the technological advances being made in the universities and foundry laboratories to give better understanding of the physics of solidification, heat and mass flow during solidification, thermodynamics and kinetics of melting and refining, and the application of these principles to practice are the teachings that the steel foundry industry must follow for the greatest advancement.

Steel foundrymen have done a remarkable job of adapting theory to practice in the past decade. Technical highlights of this period would include: use of zircon and olivine sand for cores and molds . . . producing more accurate, thinner-walled, cleaner castings in molds and cores made by shell, CO_2, ceramic, and air-set processes . . . developing new super strength cast alloys . . . applying scientific principles of gating and risering to improve internal soundness, increase metal yield, and reduce cleaning costs.

Also the following can be listed: improved welding rods and welding techniques broadened the scope of cast-weld construction . . . better quality control through more extensive inspection by x-rays, isotopes, and magnetic particles, and use of spectograph for chemical analyses . . . reduced production costs through mechanization and automation . . . use of plaster and plastics to reduce tooling costs of patterns . . . use of stress analysis techniques in establishing optimum casting design for service intended.

Leading foundry executives emphasize that technology is useless without technicians and engineers to put it to work. The shortage of high calibre, well-educated men in the foundries accounts largely for the long lag between discovery and application. Only by having enlightened personnel can steelcasters expect to stay competitive.

Is a New Concept Needed for Hot Sand Properties?

"Yes," say George J. Vingas and Arthur H. Zrimsek. Here's why:

- *Existing techniques for evaluating molding sand properties have become meaningless.*
- *Acceptable castings can be made with any range of sand properties.*
- *Sand has so many variables that it defies standardization.*

They ask for revampment of all sand practices and technology.

FOUNDRY LITERATURE abounds with articles about hot properties of sand at elevated temperatures. Inability to use hot properties as a design criteria has led the authors to critically review and comment on the contribution elevated temperature tests have made toward the production of better castings.

The hot strength range of a variety of molding and core sands used in the foundry industry today is depicted in figure 1. These sands are used to produce acceptable castings ranging in size from ounces to seven tons. Not shown in the figure are the strengths of other media, such as concrete and graphite, with values far beyond the upper limit of the graph. So evidently acceptable castings could be made in high, low, or medium hot strength sands.

A similar analysis of hot deformation, hot plasticity, and expansion leads to an identical conclusion. Figure 2 illustrates the range of hot deformation of the same sands that produced acceptable castings. Quality castings are being produced in a variety of sands possessing low, medium or high levels of hot deformation. Figure 3 shows the expansion of these same sands. Again it must be concluded that no correlation exists between this property and quality castings.

With all the standard tests listed in the sand handbook, the foundryman must still admit that no prediction can be made whether a sand will or will not produce a quality casting. Nor can he use these tests to develop better sands for improved castings.

A conflict exists in the foundry industry between the published literature, the technologists, and actual foundry practice. If the foundry industry is to improve, it must attract engineers and scientists by either supplying them with or allowing them to develop sound engineering principles which can be used to improve and control sand formulations.

Hot Compression Strength

The hot compression test was developed because it seemed logical (and for that matter it still does) that hot metal entering the mold will put a strain upon the sand. The sand must have sufficient strength to withstand this strain and prevent rupture. While the concept sounds reasonable, the writers admittedly are puzzled by the inability of the test to function as either an analytical or a design tool. Even the most rabid advocate will have to admit that air set binders and core sands, even in the most severe cases, are doing an admirable job without possessing hot strength. The same casting can be made in different foundries, each employing sands of drastically different hot strength. So hot strength, as presently determined, has little bearing on casting quality.

The usual argument against the line of reasoning presented above is that core and shell sands are dif-

The authors, George J. Vingas, and Arthur H. Zrimsek are research engineer and foundry engineer, respectively, Magnet Cove Barium Corp., Arlington Heights, Ill.

ferent than green sand and must be approached differently. The same hot metal, however, with the same ability of inducing strains and stresses comes in contact with both and has no ability of differentiating between molding media. It seems completely illogical to tackle core and green sand problems separately.

Hot Deformation and Plasticity

Hot deformation tests are presently used in connection with either hot strength or expansion of silica.

Hot strength by itself did not provide reasonable answers. Thus the hot deformation test was used to supplement it just as ductility supplements tensile strength in metals. Figures 1 and 2, however, show a variety of sands with high, medium, or low deformation in connection with high, medium, or low hot strengths. These sands produce acceptable castings, and both good castings and defective ones can be produced in a number of combinations. Sodium silicate binders have high deformation with high strength, although core sands have no hot strength nor deformation at the temperatures at which molding sands are usually tested. The same comparison could be with concrete or carbon molding media that have infinite hot strength and practically no deformation.

The relation of deformation to expansion was made by the reasoning that when sand expands it should have enough plasticity to deform instead of rupturing. There is still a variety of silica sands with various deformations that make good castings. The evidence is striking (from figures 1, 2, and 3) that sands with deformation can produce good acceptable castings.

Expansion tests of molding sands were developed from the experience and reasoning of the silica refractory manufacturers. They found that spalling occurs because of the sudden rate of expansion of silica. But they quickly learned that this property of silica could not be changed by binders, additives, or degree of compaction. They solved the spalling problem by discarding silica and introducing new materials with low and less sudden expansion.

The range of expansions of sands that produce acceptable castings, as measured with the present methods and gauges, is shown in figure 3. The top line of the range is that of the expansion of quartz; the bottom line that of sands possessing no strength to record the actual expansion that takes place, as some binders disintegrate at these temperatures. The disintegration of the binder also explains the impossible contraction of sand mixes that are reported in the literature by some researchers. Sand or quartz does not possess the property of contraction.

It appears obvious, considering the wide range shown in figure 3, that there is no correlation between expansion of sand and casting quality.

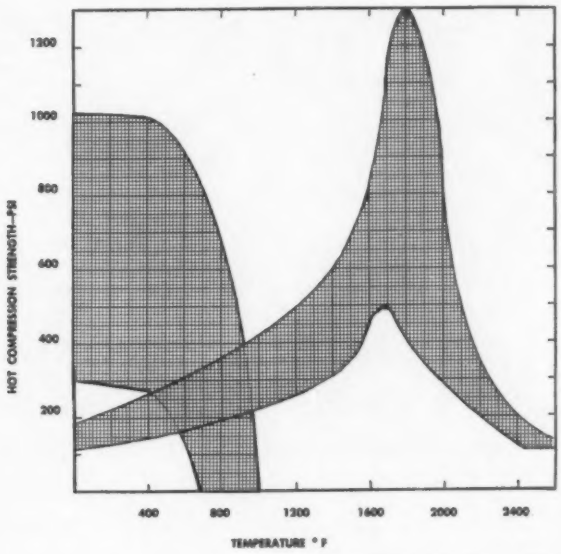
Sintering point of molding sands is measured as the temperature at which a molding sand will wet and stick to a platinum ribbon. This is far removed from the foundryman's interest. Sintering point is certainly related in some way to melting point of silica sands. Although this test is a standard in our industry, it is not used or referred to at the present time.

Hot Permeability—Hot Collapsibility

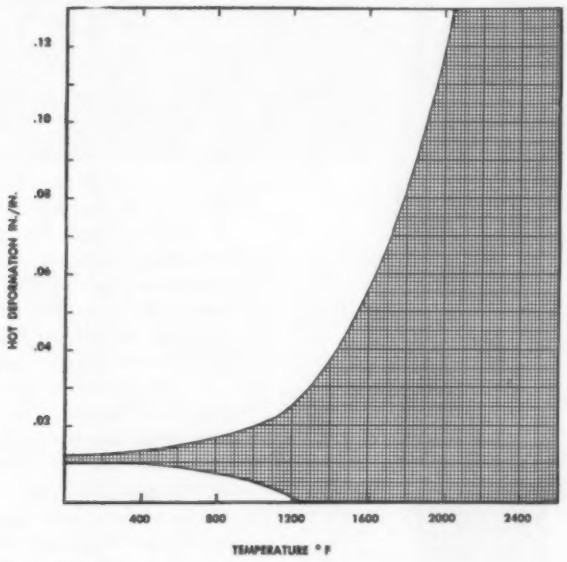
Hot permeability also becomes meaningless when observing that the shell process, with less permeability and more gas, produces as good a casting as materials with the same permeability and less gas.

Hot collapsibility was developed as a strength measure of core sands in connection with hot tears. It was found to have little value because metal chemistry, melting practice, gating, and risering factors proved to be far more influential.

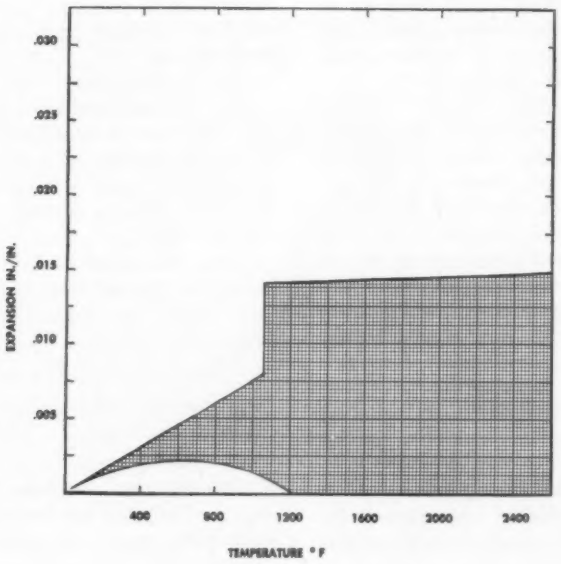
It is evident that the tests presently used cannot improve or bring about a breakthrough in green sand technology. Although the thinking behind many of these tests is sound, there appears to be a few missing links in our present knowledge of founding principles or the simulation of these tests to founding conditions is not perfect. In all probability both factors contribute to more confusion and conflict between the technologist and actual practice.



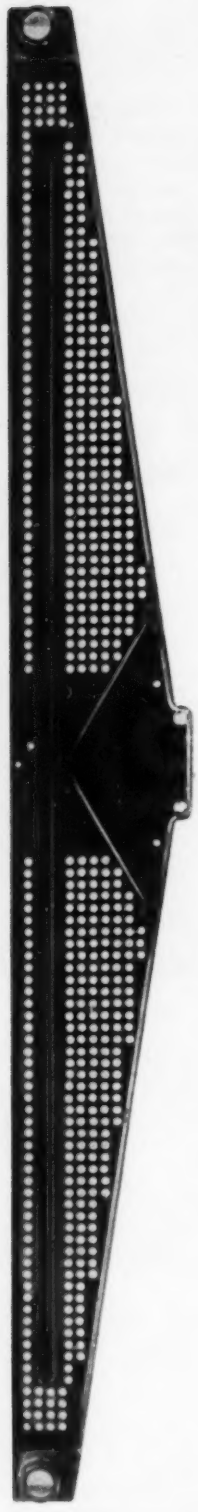
Fact 1. Chart (left) shows range of hot compression strength of molding and core sands that produced acceptable castings.



Fact 2. Chart (above) shows range of hot deformation of molding and core sands that produced acceptable castings.



Fact 3. Chart (left) shows range of expansion of molding and core sands that produced acceptable castings.



Vacuum Chamber Casting

Castings for Computers!

A new market opportunity for die casters
Converting to a zinc diecasting effected a savings of 95 per cent.
Here's the zinc diecasting breakthrough of 1960

INSTANTANEOUSLY stop a plastic tape travelling at 1000 feet per minute, or accelerate it in a matter of three milliseconds without breaking or damaging the tape. To do this required the use of a zinc diecasting vacuum chamber in an ingenious tape handler. And it was one problem confronting producers of tape handlers for computers which zinc diecasters helped solve.

Shown at left is the casting. This part was formerly "hogged out" of aluminum bar stock. *By converting it to a zinc die casting a savings of 95 per cent resulted.*

The casting has superior dimensional stability and extreme dimensional accuracy over the entire length; can be chrome plated; and the 0.007 inch slots are easily milled.

The machine handles reels of plastic tape on which information is magnetically stored for future readout. Tape travels at the extremely high speed of 1000 feet per minute. The handler is capable of rapid acceleration to this speed in a matter of 3 milliseconds and instantaneous stopping without damaging the tape. The die cast vacuum chamber has made this possible. A vacuum is pulled at each end of the chambers, creating a loop of tape measuring about 14 inches. Vacuum exists on outside of loop and atmospheric pressure on inside. A thin slot, 0.007 inches wide, senses the size of this loop and keeps it adjusted to the desired dimension and tension. The loop then acts as a shock absorber and inertia reservoir to permit rapid starting and stopping with minimum strain on the tape.

The tape handler is, itself, a necessary accessory used in conjunction with electronic computers. An average of about six such mechanisms is used with each computer installation. All of the intelligence is stored on the reels of plastic tape coated with magnetic oxide.

Many foundries are installing computer systems for high-speed inventory control, quality control of castings in process, payroll calculations, order processing, and cost controls.

New opportunities for metal casting business is everywhere. For the computer industry alone an important casting component was created that proved to be cheaper to produce by die casting than the former method.

In the few short years since the computer industry was born, 1400 large and medium-size computers have been delivered in this country. (Size is related to price: large, $1 million and up; medium, $500,000 to $1 million.)

On order, currently, is a total of 800 large and medium computers, of which 450 are large models. Each of the large and medium size

Figure 2

digital computers use six to eight tape handlers. Together, they represent a potential market of 6400 units. Each tape handler can conceivably use two die cast vacuum chambers.

In addition, there are 2500 small computers already in use, plus another 2500 on order. Each of these units can, when needed, be adapted to use tape handlers.

Quickly then, here's just one industry offering a new big market potential for die castings.

Each of the two zinc die cast vacuum chambers weighs 6 pounds, is 32 inches long, 3-1/4 inches wide and 1-1/2 inches deep, with wall thickness varying from a minimum of 0.025 inches to a maximum of 0.175 inches. A total of 515 cored holes in the part represents an unprecedented high for die casting. The long recessed groove which extends almost the entire length of the casting is cast within 0.020 inches of the surface. Then the two 0.007 inch slots are formed by milling. In figure 2 you can see the 500 ton hot-shot die casting machine and a stack of castings being inspected to meet the rigid requirements necessary for use in the digital computer.

The flatness of the outer edge of the casting must be within 0.002 inches around the periphery. A hinged glass plate is placed over the face to serve as a seal for maintaining a vacuum. Draft on all surfaces is held to a 1 degree maximum. Inside corners have a 0.005 inch radius. Some casting faces must not vary more than 0.001 inch per inch.

Castings are degreased and copper-nickel plated. Edges are then lapped and inside surface stoned and rechecked for flatness. Final operation is chromeplating.

Die for the casting is built with cast iron die blocks and prehardened cavity inserts to prevent distortion in heat treating. The flawless plated quality surface of the inside face required that this be built on the hot side of the die. Outside ejection was provided on the hot side of the die to keep the casting flat against the ejector side on opening and sufficient ejection to keep it flat when ejected.

Casting Wins Award

The vacuum chamber casting for the Ampex digital computer tape handler just recently won the "Die Casting of the Year" award.

This winning design was submitted by Victor O. Anderson, A&A Die Casting Co., Gardena, Calif. It was selected from more than 100 entries as an outstanding example of a unique application involving a substantial cost saving over the previous method of manufacture.

R. C. Kenly, vice-president, New Jersey Zinc Co., whose firm sponsored the award, presented the $1000 prize at the annual meeting of the American Die Casting Institute.

Anderson donated the $1000 to the Die Casting Research Foundation of the American Die Casting Institute for further research.

Judges for the contest were Jack H. Schaum, Editor, MODERN CASTINGS, Ralph G. Dermott, Metal Progress magazine, and Norman E. Kewley, General Electric Co.

NEW

Ore to Molten Metal By Direct Reduction

Here's a process which saves time and dollars. Iron concentrate flows into one side of an induction furnace and molten iron flows out the other. It's an important breakthrough for the casting industry.

by ALBERT DE SY
Head, Metallurgical Dept.
The University of Ghent,
Belgium

IN RECENT YEARS a great many new iron-reduction processes have been announced. The products obtained vary from sponge iron and low-carbon, high-purity iron to liquid steel and liquid pig iron. Some of them are now being tried out on a pilot-plant scale.

The process described in this article is an electric direct-reduction method which produces either liquid steel of the rimming type or a carbon-rich alloy of the pig-iron type. It needs a special high-grade iron ore, a fairly pure carbon as reductant, and electricity as the main source of energy.

Pilot Furnace

The process uses a special electric double or multi-hearth network frequency induction furnace. The special furnace design is illustrated in figure 1—a schematic drawing of a 2200 pound, 150 kva furnace specially designed for research.

The furnace itself is an electric transformer. The primary is a hollow, water-cooled, copper coil of x windings, x-y being connected. The value of x-y depends on the stirring action in the metal bath that seems ideal for the particular process. The secondary coil is the metal bath itself. Arched duct channels connect the two hearths at the bottom level. These must always be filled with molten metal.

The energy input of this furnace is regulated by controlling the voltage applied to the primary coil; if this voltage is V, then the nominal voltage on the secondary is $\frac{V}{x\text{-}y}$; this value together with the section of the channel determines the current density in the channel and controls the stirring action at constant power input. The regulation of the stirring action is extremely important in connection with the rate of the direct reduction process.

The molten bath in hearth No. 1 is supplied with carbon; because of the stirring action, carbon dissolves rapidly and migrates almost immediately from this hearth through the channels to hearth No. 2.

Iron ore—cold, pre-heated, or pre-heated and pre-reduced—is supplied to hearth No. 2 where it melts on the surface of the liquid metal bath.

When operating at 2700-2800 F. (1485-1540 C.) carbon is easily maintained at 3.5 to 4 per cent. This is important for obtaining a fast reduction rate.

Under the influence of the electro-magnetic stirring action, this liquid carburized iron now mixes with the liquid iron oxide. The process is called direct reduction because the iron oxide is reduced to molten metallic iron by dissolved carbon. A gas consisting

mainly of carbon monoxide is generated as a by-product along with slag.

The holding capacity of the pilot furnace is approximately 2200 pounds. The production capacity is about 110 pounds of iron per hour with cold Fe_2O_3-ore charges, and up to 440 pounds per hour with preheated and prereduced ore charges. A production capacity of 440 pounds per hour requires a preheating temperature of 1650-1835 F. (900-1000 C.) and a high ore prereduction of some 80-90 per cent.

The ore is supplied by a small rotary kiln approximately 10 feet long. To start the process, the secondary winding, i.e. the metal bath, must be closed. Also the furnace must contain sufficient liquid metal to fill the channels. From this point operation is started by simultaneously supplying carbon to the carburizing hearth as well as ore to the ore-reduction hearth.

Furnace Fills Progressively

As reduction goes on, the furnace is progressively filled to its 2200-pound metal capacity. During the reduction period the furnace is closed, and the slag produced from the ore gangue is accumulated in the furnace.

When the furnace is filled, the spout is opened, the slag tapped-off. Approximately 1540 pounds of the 2200 pounds of metal is tapped and 660 pounds is kept in the furnace to start the next reduction cycle.

The limitations of the laboratory pilot furnace mainly concern the type of ore. As the furnace is filled in one operation from the starting level (660 pounds) to the final level (2200 pounds) the gangue of the ore corresponding to 1540 pounds of iron, and the eventual additions to obtain a basic slag, are transformed to slag. The slag volume must be limited for economic reasons (reduction rate is lowered by dilution) and for practical reasons (too large a slag volume foams during heavy boiling).

Thus the ore must be very rich, for example, maximum 2 per cent acid gangue which necessitates basic additions; or maximum 4 per cent basic gangue requiring no additions. The lining of the furnace is basic. Magnesite bricks and magnesite ramming mix are commonly used.

Using the tilting-type laboratory furnace, the process is necessarily discontinuous. A continuous process would be highly desirable for industrial applications. This is possible providing the production capacity achieves a minimum of 2 to 4 tons per hour.

Overflow Rate

At this production rate, continuous overflow of the iron and slag can take place. The industrial furnace should be a fixed or non-tilting furnace operating at constant metal level. The rate of overflow then corresponds to the production rate.

One disadvantage with this type furnace is the localized lining attack at the constant slag level. The lining attack depends on slag composition, slag temperature, and lining-slag interface temperature. Slag composition can be modified so it is basic; the slag temperature is low, about 2800 F. (1540 C.). A unique advantage of induction heating compared to arc heating is the low slag temperature—a maximum of 2800 F. (1540 C.). Hot slag gives a severe lining attack. The lining-slag interface temperature should be kept below the melting temperature of the slag by means of cooling boxes in the lining at the constant slag level.

Economic Requirements

1. Lining life is important for economic production. Lining attack by the slag may be limited as already stated. Molten iron containing 3 to 4 per cent carbon at 2800-2900 F (1540-1595 C.) does not attack the basic magnesite lining. Moreover there are practically no limitations to lining thickness for this type of induction furnace. Lining must be thin for the crucible type induction furnace because of the current yield.

2. Power consumption is at least as important as lining life. When supplying cold rich ore, power consumption in an industrial furnace amounts approximately to 1600 kwh per metric ton (2200 pounds) of iron. For economical production the furnace should be supplied with hot pre-reduced ore—the higher the pre-reduction stage, the more economical the process. Power consumption decreases and production rate

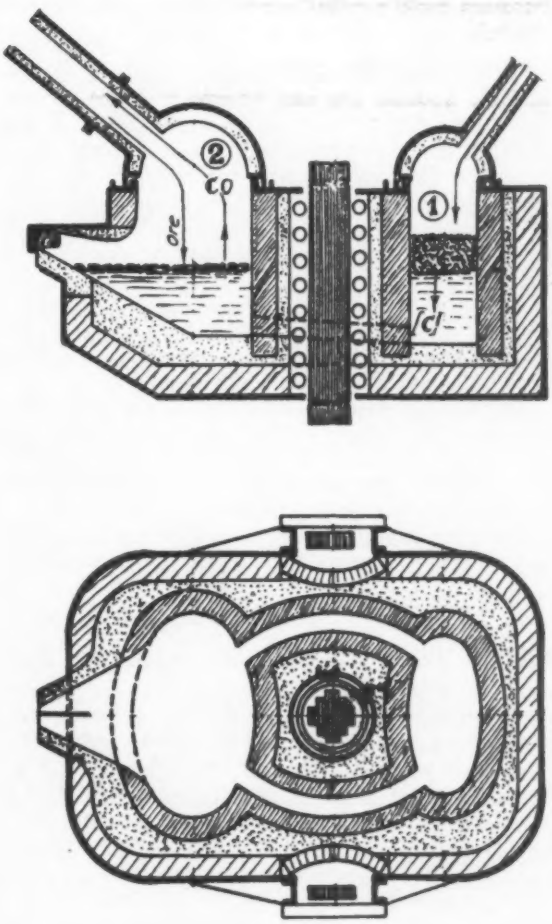


Figure 1

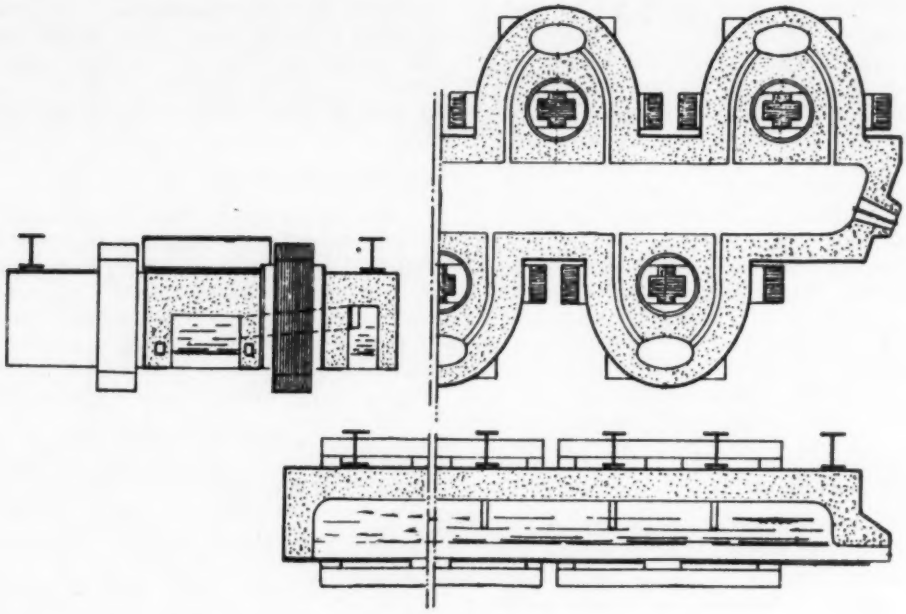


Figure 2

increases rapidly with increasing pre-reduction (see Table 1).

3. Raw Materials. Tilt furnace operation requires rich ore because the slag volume must be limited. When operating with a continuous overflow of iron and slag, limitations concerning the ore are not nearly as severe. Slag volume does not build up since the slag is continuously removed. Nevertheless one should not operate with ore containing less than some 60 per cent Fe because melting slag by electricity is always expensive.

Preferably the ore should be fine. Fine ore mixed with the reductant in the pre-reduction rotary kiln is easier to reduce to a high pre-reduction state. Thus ore enrighment processes are ideally suited.

Anthracite fines are well suited as reductant. Part of it must be charged in the carburizing hearths and should be low in ash; another part is mixed with the ore charge for pre-reduction in the rotary kiln. Here the ash content is not so important.

The process applies only to rich ore and a carbon rich reductant. Moreover, there are power limitations and consequently limitations of the production capacity of a furnace unit.

Actually the energy input per coil and secondary channel is limited to some 500 kva. Therefore a furnace with three sets of coils and channels corresponding to the three phases of the alternating current has a maximum rate of 1500 kva.

Theoretically, at least, one can build furnaces with two, three and even more multiples of 3 sets of coils and channels. Energy input and production capacity should then be unlimited. However, at this stage, we have no experience of the behavior of such long and narrow furnaces. It seems reasonable to consider furnaces rated 3000 kva of the two times 3-phase type. Figure 2 represents such a furnace.

Table 1—Power Consumption, Production Ratio

Charge	Reductant (carbon) per ton iron	Power Consumption in kwh/ton	Production per hour (3000 kva furnace)
Cold Ore	320 kg	1600	1.7 t*
80-90 per cent pre-reduced ore at 1800 F	450 kg	600	4.5 t*

*t = metric tons; tons = metric tons

Industrial Plant for Steel Production

With the continuous overflow type furnace, the pig iron produced can be converted in a second step to steel. According to the flow-sheet (figure 3), the iron-carbon alloy flows continuously into an induction heated receiver of the single hearth network frequency type.

Figure 4 shows a schematic drawing of this type furnace, practically unknown in the United States, but now very popular in western Europe. In the last few years some 100 of these furnaces have been installed in European iron foundries. They are used for melting foundry returns or making synthetic cast iron from steel scrap or operating in duplex with cupolas.

The furnaces are operated continuously or the bottom metal is maintained liquid overnight. The furnaces have an average lining lifetime (with acid lining) of four to six months before relining becomes necessary. The power consumption is very low, close to 500 kwh per ton in melting cold scrap charges. For large furnaces of 1000-1500 kva, power consump-

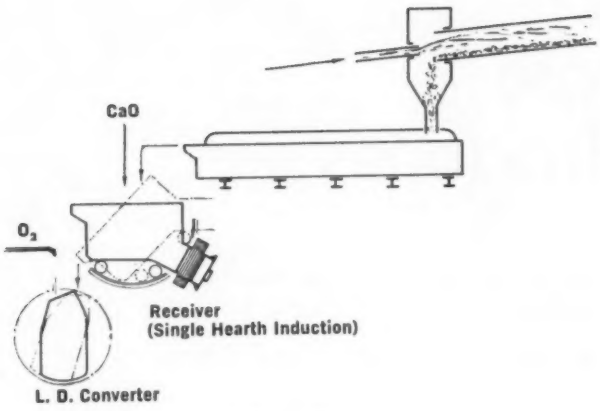


Figure 3

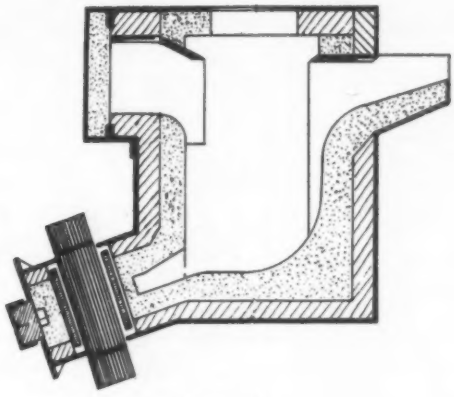


Figure 4

tions of 420-450 kwh per metric ton have been obtained.

Two furnaces of 8 metric tons (17,600 pounds) capacity each, can be coupled and connected to one 750 kva transformer. During the day they operate in duplex with a hot-blast cupola melting 100 per cent poor quality steel scrap. Overnight they melt scrap and foundry returns. The production in this foundry is 150 tons per day with an average power consumption over the year of 200 kwh/metric ton (melting overnight and duplexing during the day).

This proves that channel type induction furnaces can act as a receiver and also be used for melting or keeping molten pig iron, cast iron or any carbon rich liquid iron at 2800-2900 F. (1540-1595 C.). They are reliable and inexpensive to operate.

The liquid iron is desulphurized by blowing lime powder into the metal bath contained in the receiver. This is another fast developing European desulphurization process applied to cast iron. Iron containing 0.2 and 0.3 per cent sulphur may be desulphurized to 0.02 per cent sulphur or even less than 0.01 per cent if, at the end, one blows some CaC_2 into the metal bath. The desulphurized iron from the receiver is then transferred to an LD-converter for steelmaking.

Industrial Plant for Cast-Iron Production

This process looks very attractive for iron foundries having a daily production of 100 or more metric tons a day. After desulphurization in the receiver it is easy to adjust composition by adding ferro-silicon, ferro-manganese, and, if carbon content is too high, some steel scrap.

Two receivers are needed: No. 1 is progressively filled; the iron is desulphurized; and its composition and temperature are adjusted. No. 2 is emptied in pouring the castings. Composition and temperature of the iron may be adjusted within narrow limits. Foundry returns may also be charged into the receiver and converted back to liquid iron of good quality.

Production of quality cast iron is only interesting if the cost is lower than that produced by conventional methods. The cost of the molten iron is easy to calculate (approximately) on the basis of power consumption and raw materials; to this you must add labor, overhead costs, amortization, etc.

For steel production, investment should be about $40 per annual metric ton (2200 pounds) of ingots. For cast iron production, investment should be close to $30 per annual metric ton of liquid cast iron.

Depending on the cost of energy and raw materials and on local circumstances, the liquid cast iron produced should cost between $40 and $50 per metric ton. This is much cheaper than the liquid cast iron produced by conventional cupola melting.

Conclusion

Previously it was believed that this process was only, or at least mainly, of interest to under-developed countries having rich ores and no coking coal. Today the process appears to have even greater interest for industrial countries because it seems to be competitive with conventional smelting and melting processes.

While many new reduction processes have been proposed in the last years, few of them are able to reduce the ore up to 100 per cent. Reducing the last 10 or 5 per cent is, in many new processes, difficult and expensive. Even fewer new processes deliver liquid iron suited to the needs of foundrymen.

Published through the courtesy of the Electrochemical Society, Inc.

Read page 122 in this issue for information on a new pilot plant operation of a direct reduction process . . the first in the United States.

How to Choose the Right Refractories

1. You have a choice of four processes: Power-Press, Extrusion, Air-Ramming, and Hand-Molding.

2. You can pick from ten materials that vary in heat and chemical stability.

3. But make sure that you get the right combination for your foundry needs.

This will mean longer service life and dollars in your pocket.

by F. H. FANNING
Harbison-Walker Refractories Co.
Pittsburgh, Pa.

THE PROPER selection of refractories for various foundry applications is governed by knowledge of the processes and materials used in their manufacture. The classes of refractories most commonly used in the foundry are: low-duty, medium-duty, high-duty and super-duty fireclay brick, and high alumina brick. And the four principal processes of manufacturing standard brick sizes and special shapes are: power-press, extrusion, air-rammed, and hand-molded.

1. Power-Press Process

A large variety of refractory crude clays, calcined grog, and other raw materials are used to manufacture power-pressed brick. Brick made by the power-press process have excellent dimensional uniformity, high strength, and virtual freedom from warpage and forming defects, such as laminations.

Brick made on the power press from refractory fireclay mixes containing coarse particle sizes usually have excellent resistance to thermal spalling. This physical property combined with dimensional uniformity is an important factor in many applications. A good example is the super-duty fireclay brick used in malleable bung frames.

2. The Extrusion Process

This process produces the standard brick sizes and special shapes from a column of clay that is formed by a die on the front of an extrusion machine. The extrusion process usually achieves the maximum density and highest strength, while the power-press process achieves the closest possible size tolerance, the most uniform workmanship, and the ultimate in spalling resistance.

Compared with all other methods of manufacture, the extruded brick are usually stronger, denser, and lower in porosity.

Extruded brick generally have low permeability, and excellent resistance to penetration by molten slags, metals, and various fluxes. High strength, both hot and cold, is characteristic of brick made by this process and contributes to the excellent resistance they have to abrasion and erosion.

3. The Air-Rammed Process

Air-rammed shapes are produced in steel-lined molds with pneumatic hammers from clay mixes similar to those used in the power-press process. The physical properties of these brick compare favorably with those of the power-pressed brick. They have excellent workmanship and dimensional uniformity.

4. The Hand-Molded Process

When special shapes are too large or too intricate to be manufactured by machine methods or when the quantities ordered are too small to justify the expense of making molds for another proc-

ess, brick may be hand molded.

Hand-molded brick are equal in refractoriness to comparable brick made by any of the other processes. They have good resistance to thermal spalling but compared with air-rammed brick they are more permeable and not quite as resistant to penetration by destructive fluxes. When extruded blanks are used for making hand-molded shapes, the physical properties of density, porosity, and mechanical strength are improved.

The Materials

Refractory fireclay brick of the various classes . . . low-duty, medium-duty, high-duty, and super-duty . . . are manufactured from selected flint and bond clays and calcined grog. The brick of each class are made from raw materials of appropriate refractoriness and physical properties.

The American Society for Testing Materials classifies fireclay refractories with respect to their refractoriness as follows:

1. A low-duty fireclay brick shall have a minimum P.C.E. (Pyrometric Cone Equivalent) of Cone 19 (corresponding to a softening temperature of 2805 F).

2. A medium-duty fireclay brick shall have a minimum P.C.E. of Cone 29 (corresponding to a softening temperature of 3020 F).

3. A high-duty fireclay brick shall have a minimum P.C.E. of Cone 31½ (corresponding to a softening temperature of 3090 F.).

4. A super-duty fireclay brick shall have a minimum P.C.E. of Cone 33 (corresponding to a softening temperature of 3170 F).

High-alumina refractories are made from high-grade diasporitic flint clays, diaspore, kyanite, sillimanite, bauxite, synthetic mullite, and fused or tabular alumina. The refractoriness of high-alumina brick is dependent upon their alumina content.

Air Furnace Refractories

Virtually all of the various classes of fireclay brick and high alumina brick are used to advantage in the foundry. For most economical service it is necessary to select the refractory that will provide the optimum combination of chemical and physical properties best suited for each application.

In malleable foundry air furnaces, the bungs, sidewalls, and bottom are generally built with super-duty fireclay brick. There are a number of furnaces in which high-alumina brick are used for lining the bottoms; and either high-duty, super-duty, or high-alumina brick for lining the sidewalls. However, this discussion considers only super-duty fireclay brick.

The bung brick are power-pressed from a mix having a coarse grind. These brick must be extremely resistant to thermal spalling and they must be relatively free from warpage to minimize cracking when the bung frame is tightened.

The brick used to line the sidewalls and bottom of the air furnace are generally vacuum power-pressed. Dimensional uniformity is important to the brick used to build these sections. The bottom must lay up tight with joints of minimum thickness to prevent metal from penetrating into it and causing subsequent dislodgement. The walls must also lay up tight to prevent joint erosion. The physical properties of high density, low porosity, and good spalling resistance are very necessary to the successful performance of the brick in the malleable air furnace.

The introduction of vacuum power pressing has made it possible to produce cupola blocks with physical properties closely corresponding to those of extruded brick. Supplemental benefits derived from this process are closer size tolerance and improved spalling resistance.

Cupola Refractories

Cupola taphole blocks for the conventional acid-process operation are usually hand made or air-rammed. To obtain maximum density and minimum porosity, the hand made shapes are generally formed from extrusion machine blanks. Power-pressed tap hole and slag hole blocks are advantageously employed in some cupola operations. This is particularly true in cupolas having high melting rates. The service conditions may warrant the use of high-alumina brick, or even carbon or silicon carbide. If the shapes are too intricate or too large for power pressing they can be made by the air-rammed process. These shapes will have physical properties closely corresponding to those of power-pressed brick.

The tap hole, dam, and skimmer on the front slagging cupola are areas in which power-pressed brick are generally favored. Since the entire operation of the cupola depends on the successful performance of the brick in these areas, many operators recognize the advantages of high-alumina brick.

Ladle Refractories

Desulphurizing ladles and forehearths require refractories that can withstand the corrosive attack of the alkaline fluxes employed. These fluxes are best resisted by basic refractories. However, the slag from the cupola is siliceous and will readily react with basic refractories. The best compromise is a brick of very high alumina content, usually in the 90 per cent alumina class or higher. If these high-alumina brick are to perform satisfactorily it is important to use a mortar with approximately the same refractoriness as the brick.

Inclusions in steel castings have sometimes been traced to fireclay and ganister ladle linings. There have been similar experiences with basic ramming mixes and even conventional ladle brick. In some cases, inclusions have been markedly reduced when ladles were lined with power-pressed or extruded high-duty or super-duty fireclay brick. To prevent joint erosion, the mortar used with these brick must be equal to or preferably greater in refractoriness than the brick.

An excellent example of a tile design for which the extrusion process serves best is gate and runner brick. A blank cut from the extruded column is punched on a vertical reforming press. The male and female shapes are formed on this press with spinner dies that contour the ends to their final dimensions. These tile are very resistant to metal erosion and permit much faster pouring speeds than sand gating systems.

If foundrymen understand the fundamentals of refractories as applied to their equipment and take advantage of the inherent physical properties, an improvement in refractory service life can be realized and over-all refractory costs may be reduced.

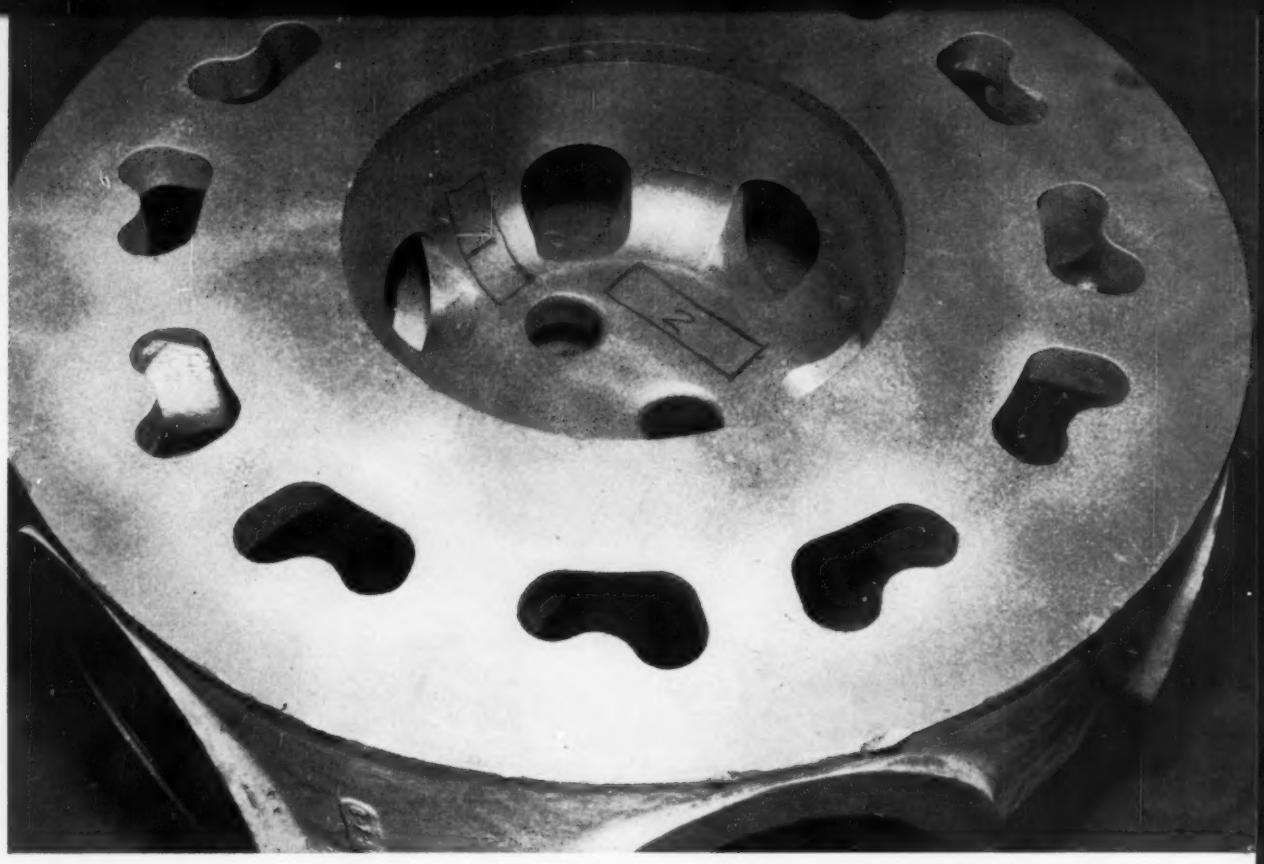


Figure 1

Squeeze the Safety Factor, Allow Less for Ignorance

T. O. Kuivinen, design engineer, Cooper-Bessemer Corp., Mt. Vernon, Ohio talks frankly about modern day design engineering. He advises:

- *Foundrymen should correlate casting strength to values obtained from test bars.*
- *Designers need foundrymen's guidance during casting planning stage.*
- *Better communication between designer and foundrymen is needed.*

If foundrymen will follow this advice metalcastings will occupy a stronger position in future designs.

IN OUR BUSINESS—the manufacturing of large engines and compressors—the engineering department is both the designer and the buyer. Our Corporation has captive foundries producing several grades of irons, and we purchase steel, bronze, aluminum, and magnesium castings from outside foundries. In all cases castings are designed, specifications are written, and inspection requirements are issued by the engineering department.

The designer and the foundryman have the common objective of furnishing the customer a functioning product. Foundrymen should measure their success in providing customers with top performing products. And casting designers should have the same objective.

Strength in the casting, casting soundness, dimensional control, communication between designer and foundryman, and economics are areas in which the desires of the casting designer should be considered.

Through the foundry's laboratory facilities the designer obtains data concerning tensile strength, shear strength, endurance strength in fatigue, and other properties of the materials used in various components. Such information is quite valuable and is used during design of the casting. Standard testing procedures, as outlined by the American Society for Testing Materials, are widely accepted. But, the ASTM procedures are directed at a test bar which is cast attached or separately at the time the casting is made. Usually all the data offered to the designer are determined from such test bars.

The designer needs to have assurance that the

strength level in the casting will be at the level used during his design computations. He is entitled to expect the metal in the casting to be at strength levels attainable repetitively in production castings. The ASTM procedures and specifications relate only to the quality of the metal in the test bars. Strength levels determined from test bars may or may not be representative of the strength in important sections of the casting.

Many factors in casting production may result in large differences in strength. For example, the casting will probably have different cooling rates than the test bar. Therefore, one might expect different strength characteristics in the casting than found in the test bar. The foundryman should have suitable facilities for determining the material strength attainable in all types of castings. Yet there are no standardized procedures established. Each foundry's laboratory must develop means for determining and correlating casting strength to the values obtained from control test bars.

Cooper-Bessemer Corp. produces many different types of parts. Some of these are scrapped because of machining errors or various types of flaws. Being complex and usually fairly large, such scrapped castings have many perfectly sound areas. Therefore, we cut up such castings and make test bars from representative sections. Strength data is collected and correlated with information obtained from the usual control test bar.

Recently a compressor cylinder head was scrapped due to a machining error. Figure 1 shows this casting from the face where it bolts against the cylinder body. Bolt holes had not been drilled. Two test bars were cut from important portions of the head. The rectangle marked "1" in the photograph indicates the wall from which a test bar was cut. This area contains the highest stress, as demonstrated by earlier fatigue testing of the cylinder. A second test bar "2" was taken from the cylinder head end wall.

Results from these actual casting test bars were:

Test bar number	1	2
Tensile Strength, psi	45,500	39,300
Brinell hardness	183	179

Chemical analysis of material from the casting was: total carbon–3.00 per cent, silicon–1.59 per cent, manganese–0.81 per cent, phosphorus–0.071 per cent, sulphur–0.083 per cent.

Arbitration bars cast from the same ladle of iron had a tensile strength of 49,000 psi.

Such information helps the foundry realize the strength levels needed in the control test bars to assure continuing specification strength levels in future castings. Chemical analysis correlation is easily continued by checking drillings from production castings. Such studies and correlations must be a continuing effort in order to maintain worthwhile useable data.

The foundryman can instill a high level of confidence by determining strength levels obtainable in castings. Through correlation of this knowledge with test bar data he gives the designer a feeling of confidence in what he can expect in the castings.

It's more difficult to be sure that all castings are sound. Shrink areas, dross, and blow holes can't be tolerated in today's modern machines. Load demands on components are high. Careful design for good stress distribution in limited space is essential. Ability to with stand dynamic loads without fatigue failure is absolutely necessary.

Is the Casting Sound?

Stress concentrations caused by design shape and function requirements cannot be avoided entirely. Therefore, stress concentrations caused by shrink or blow holes introduce quite high risk of casting failure in service. Experimental work is required to find means for eliminating shrink and dross. Sometimes the latter can be handled by design alteration so that the dross occurs in an area where it is removed by machining.

Service failures due to flaws discourage repeat orders for a product just as well as failures due to poor design. Neither designer nor foundryman is interested in losing business, but both will if castings fail in service because of unsoundness. An understanding of the problems involved in making sound castings is required of the designer. Therefore the designer expects this knowledge to come from association with the foundryman. The designer needs the foundryman's guidance during the casting planning stage so that foundry problems are minimized.

Stress Distribution Important

Careful design study from the casting viewpoint alone is just as essential as from the functional viewpoint. Once a decision is made future change may be difficult, for redesign of the entire machine might be necessary. The designer may expect soundness in castings produced by the foundryman. But he doesn't expect it without consideration of the foundryman's problems while the casting is in the design stage. Quite often a casting design may be arranged for best location of feeder heads and gates. Wall intersections may be studied and modified to avoid hot spots and shrink porosity. Other requirements are considered in like manner.

Dimension is probably more easily controlled than strength and soundness and it is just as important. The designer today expects close adherence to the dimension and shape specified. Space limitations in the highly loaded modern machine force design practices that utilize to the limit all sections of the casting. Design skills have increased through the use of stress-measuring such as electric strain gauges, brittle lacquer, and photo-elasticity. One has to almost run to keep pace with the new development in loading and stress-measuring techniques.

Research laboratories are also providing new knowledge concerning the behavior of material under various types of loading. Nearly all machinery is subject to cycling load in a specific manner. Information is now available concerning the capability of material to endure such loading without failure in the lifetime desired for the machine.

The knowledge of behavior of material under cy-

The designer bent across his board,
Wonderful things in his head were stored.
And he said as he rubbed his throbbing bean,
"How can I make this tough to machine?
If this part here were only straight
I'm sure the thing would work first rate.
But 'twould be so easy to turn and bore
It never would make the machinists sore.
I better put in a right angle there
Then watch those babies tear their hair.
Now I'll put the holes that hold the cap
Way down in here where they're hard to tap.
Now this piece won't work, I'll bet a buck,
For it can't be held in a shoe or chuck.
It can't be drilled or it can't be ground
In fact, the design is exceedingly sound."
He looked again and cried —"At last—
Success is mine, it can't even be cast!"

Famous poem of the casting industry pinpoints Kuivinen's ideas. Author Unkown.

clic or fatiguing loading is now available to designers. Also good textbooks and technical reports aid designers in using this knowledge for the design of parts that will endure fatiguing loads.

The improved designs resulting from using such modern techniques places greater demand on the foundryman to control production closer to specifications. The designer now obtains greater performance from less space and material by squeezing down on the "safety factor" and allowing for less "factor of ignorance". This requires careful adherence to specified dimension, and assurance of specified strength in the casting.

One of the ingredients for success can be the development of better communication between the designer and the foundryman. Confidence is developed through continuing association. Naturally the designer cannot be an expert foundryman. But, he must understand the manufacturing problems of the foundryman so that he can create designs that can be produced successfully and economically. He needs to consult the foundryman during the designing of a part so that the part is producible as well as functional. The design layouts are discussed with the foundryman and the pattern maker. Together they resolve the questions of production in order to have sound, flaw-free castings at lowest possible cost.

A Designer Watches Costs

A good designer is cost conscious. His own personal desires as to geometry of a casting are easily transformed once he is advised concerning the comparative costs of various approaches. The foundryman may suggest an alternate approach to make feeding easier, or to minimize cleaning time, and so on. At this stage the foundryman learns of the quantity to be produced. This affects the type of pattern to be built and the molding method to be used. Either of these could influence the design shape and dimension. Many other factors can be clarified, all in the interest of desired performance in the product at minimum manufacturing cost.

In like manner, the foundryman isn't expected to be an expert designer. But, he is entitled to know something about the designer's problems and the function of the casting he is to produce. Effective communication between the two helps to attain the common objective. Thus we recognize that the product is the result of team effort on the part of both foundryman and designer. A successful team must have continuous communication among the several specialists who contribute to the manufacturing of the product. The man who deals directly with the foundryman is only his immediate customer. The real customer, the product user, measures the success of the foundryman-designer team by the performance of the casting in the product.

Our experience in the manufacture of large heavy-duty machinery has demonstrated the need for close communication with the foundryman. Through consulting, experimenting, and correlating information the foundryman builds the high level of confidence which the designer must have. I can safely say that some manufacturers have substituted welded fabricated parts where castings had been used because their designers lost faith in poor performing castings.

We believe the casting process is a realiable, economical method for producing machinery components. We also believe there is a place for weldments in our machinery. The designer decides on the method of fabrication by knowing the service function and the manufacturing cost involved. Creating and producing machinery for the best performance at minimum cost must include consideration of forgings, rolled stock, weldments, and castings in the many different types of materials available for all of these processes. Each has its place. The castings' position is a real one and is growing.

Casting for Defense

The armed services continue to push their demands for higher strength castings. Here's how standard aluminum alloys can be made to reach beyond their normal capabilities by rapid cooling and special heat treatment. By using aluminum permanent molds or aluminum chills in shell molds, foundrymen can meet more of the future procurement needs for ordnance components

by M. L. Slawsky and F. A. Heiser
Watervliet Arsenal
Watervliet, N. Y.

Recent work indicates marked improvement in aluminum castings by casting into chilled shell (or sand) molds and anodized aluminum permanent molds, plus strict control of foundry variables and proper heat treatment. Improvements are effected by the rapid cooling imparted by the mold upon the structure of the metal. The result is a denser structure with finer grain size and finely dispersed constituents. Coarse structures result from slower solidification rates.

Permanent mold casting has been used extensively to influence properties of castings. Cast iron is the most commonly used permanent mold material. By substituting a metal capable of removing heat more rapidly, an even greater improvement can be realized. Anodized aluminum molds are markedly effective in this capacity. In certain instances only specific critical sections may require high strength, or the design of the component may be such as to prohibit the use of a metal mold. Rapid cooling can then be effected by selectively chilling the casting at the desired area. Aluminum chills in a sand or shell mold achieve this need effectively.

Aluminum alloys divide themselves into two classifications—heat treatable and non-heat treatable. The heat-treatable type contains certain elements which show considerable solubility in aluminum at elevated temperatures but limited solubility at lowered temperatures. The strength of these alloys actually depends upon this phenomenon.

Generally the heat-treatable alloys achieve the highest properties. A two-stage treatment is usually applied. In the solution treatment stage, the casting is heated to a temperature sufficient to dissolve the alloy in the aluminum, then quenched to retain the solid solution. Second stage is the aging cycle in which hardening and strengthening result from the precipitation of the alloying constituent from the supersaturated solution.

The objective of this investigation was to develop aluminum castings for two specific components—the sight bracket (figure 1) and the yoke (figure 2) of the 81 mm mortar. A combination of high strength with suitable ductility was desired. The bracket, formerly made of steel, was to be cast in a permanent mold because of the over-all strength requirement. The yoke was to be cast in a chilled shell mold to obtain maximum effects at the critical section. This replaced a conventional sand casting which failed in user tests.

The program was designed to achieve maximum properties by selection of suitable alloy and determination of optimum heat treating cycle.

Based on typical properties ob-

Figure 1

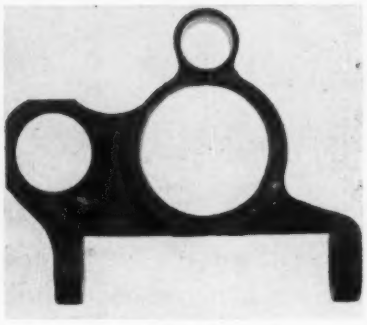


Figure 2

Table 1—Chemical Composition (Typical)—Per Cent

Alloy	Cu	Si	Mg	Zn	Fe	Ti	Al
B195	4.5	2.35	0.10	0.10	0.25	0.03	Rem.
195-10	4.5	0.10	0.10	0.10	0.27	0.01	Rem.
A356	0.08	7.00	0.33	0.10	0.13	0.12	Rem.
Ternalloy 8	0.03	0.25	2.3	4.8	0.24	0.07	Rem.
ZZO	0.17	0.22	9.7	0.10	0.18	0.08	Rem.

Table 2—Mechanical Properties—Permanent Mold

Alloy	Heat Treatment*	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)
B195	1000-30, 350-13½	51,000	38,000	3.0
195-10	1000-24, 350-16	49,000	32,500	7.2
A356	1000-8, 310-4	40,000	27,300	3.6
Ternalloy 8	810-21, 300-12	55,400	53,000	1.5
220	810-16	43,000	23,600	11.5

*Heat Treatment—Solution Treatment Temperature (F.) and time (hours), and Aging Temperature (F.) and time (hours)

Table 3—Mechanical Properties—Chilled Shell Mold

Alloy	Heat Treatment*	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)
B195	1000-16, 310-10	44,000	33,000	3
195-10	1000-24, 350-14	53,000	43,000	3
A356	1000-16, 400-2	44,500	37,000	10
Ternalloy 8	810-21, 300-4	56,000	51,000	3
220	810-12, 300-12	54,500	27,400	10

*Heat Treatment—Solution Treatment Temperature (F.) and time (hours), and Aging Temperature (F.) and time (hours)

tainable in castings, alloys B195,220 and 356 were selected for testing. This list was later expanded to include Ternalloy 8, and modifications of those alloys already under test, specifically 195-10 and A356, in which iron is restricted to a maximum of 0.20 per cent. Chemical compositions are in Table 1.

Test castings of each alloy were made in: (a.) A specially prepared anodized aluminum test bar mold, for sight bracket applicability (figure 3); and (b.) A chilled shell mold for the yoke (figure 4).

Various heat treatments were tried on each alloy to determine that which resulted in optimum properties. Those alloys exhibiting desirable strength and ductility were then cast in the anodized aluminum sight bracket mold (figure 5) and x-rayed for soundness. This step was unnecessary for the yoke as it had already been performed concurrent with alloy evaluation tests.

Procedural Details

Because of the small quantity of castings involved, no elaborate molding procedures were devised. The sight bracket and test bar permanent molds were coated with an insulating material, preheated to 400 F., and clamped to prevent flash. No coating or preheat was used for the yoke molds which were bolted together. Purchased alloy ingots were melted in silica crucibles without any special additions. After heating to the desired temperature, maintaining superheat at a minimum, nitrogen was introduced to degas the melt. Dross was removed with a refractory coated steel skimmer.

Pouring temperature depended on the alloy. Temperatures of 1300 ±15 F. and 1350 ±15 F. were used for the sight bracket and yoke, respectively. Molten metal was poured directly from crucible into molds, no intermediate ladling.

Optimum heat treatment was determined through a series of tests on samples with various solution treatment and aging cycles. The number of tests were minimized by observing the trend in mechanical properties with a change in aging. A graph of mechanical properties vs. aging variables indicated the alteration of heat treatment necessary for satisfactory results. A

tentative goal of 40,000 yield strength and 8 per cent elongation was established. If a series of tests indicated that these properties could not be attained with a specific alloy, experimentation with it was discontinued.

The final selection of alloy and heat treatment was based upon ability to produce a sound casting with maximum mechanical properties.

Results

The results of the investigation are summarized in Tables 2 and 3. These are the best combinations of properties obtained for each alloy. For production weapons, five sight brackets and twenty yokes have been produced with the properties cited.

The results of this report are due to the cumulative action of three main effects:

1. The refinement of structure and reduction of microporosity through the employment of molds with rapid heat transfer rates.

2. The reduction of iron contamination through use of high purity ingots and control of melting practice.

3. More effective heat treatment through modifications of standard practices.

The properties presented in Tables 2 and 3 represent the optimum combinations of strength and ductility obtained for each alloy tested. In many instances the strength or the ductility could have been increased separately by varying the heat-treating cycle. However, each increase in one property was accompanied by a corresponding decrease in the other. For example, a Ternalloy 8 yoke casting showed a 61,000 psi tensile strength and 49,000 psi yield strength but only 1.3 per cent elongation.

Slow cooling in sand molds forms a coarse grain structure with detrimental segregation and microshrinkage. These account for most of the relatively inadequate mechanical properties generally associated with aluminum castings. Standard permanent mold casting and die casting practices with their increased cooling rate improve the properties somewhat. Still further improvement results from the even greater heat transfer rates possible

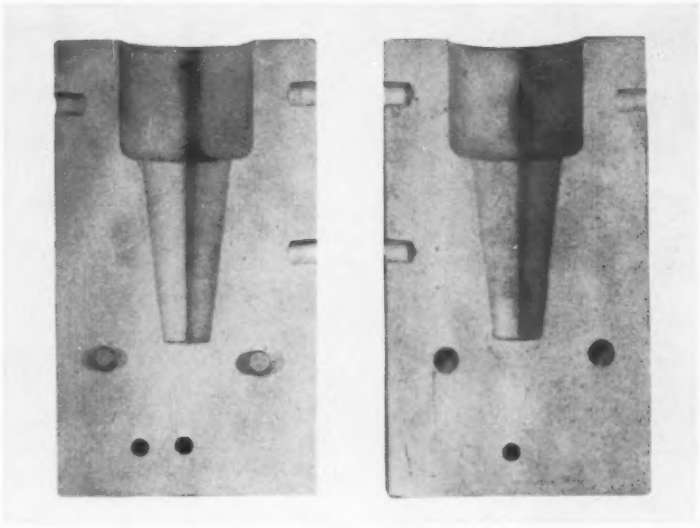


Figure 3

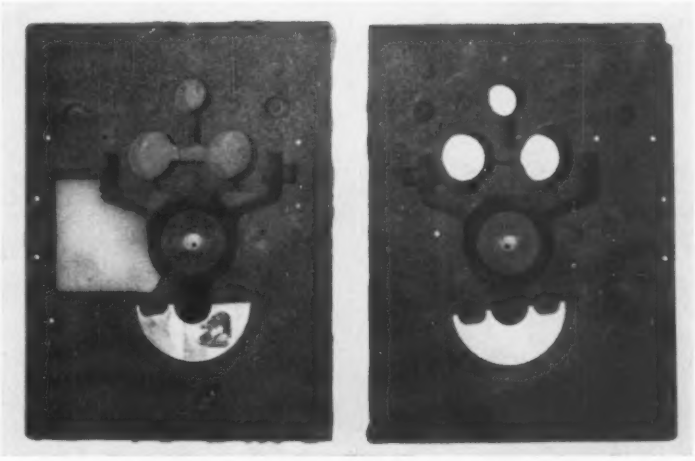


Figure 4

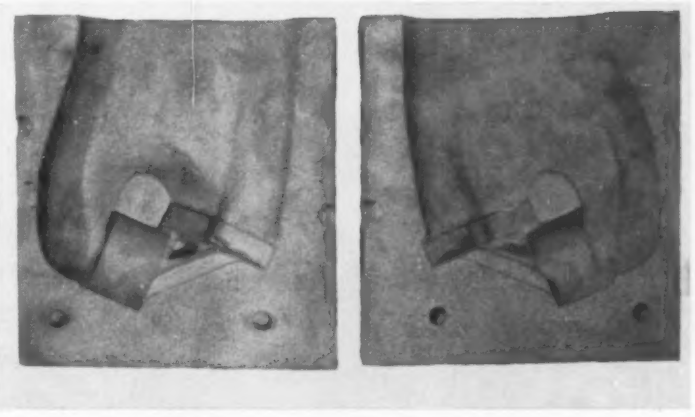


Figure 5

U.S. Army Photos

with the techniques described in this report. The fine grain structure developed allows more complete solution in the solution-treatment phase.

A second influence on the degree of solution is the time at temperature. By increasing the time markedly, solid solution is more complete than obtained with standard practices.

Alloy strengthening comes from precipitation of constituents from solid solution during aging. A wide range of properties is possible by varying the aging parameters.

No attempt was made to resolve the quantitative effects of iron contamination. Even when present in minor amounts, iron tends to form brittle compounds, thereby reducing ductility. Special commercial alloys, low in Fe, were purchased. As seen in Table 1, even the standard alloys showed iron contents well below the maximum. This fact accounts, in part, for the properties obtained.

Not all the alloys tested were improved by the techniques employed. The properties obtained with 220 alloy are similar to those obtainable in sand castings. Improved tensile strength noted with artificial aging of this alloy is probably due to an acceleration of the change which usually occurs when this alloy ages naturally. However, the yield strength remains comparatively low. In addition, properties are erratic and difficult to reproduce. This might be due to its inherent tendency toward microshrinkage and high drossing. Because of these and an inability to produce a sound casting, experimentation with this alloy was curtailed after the initial investigation.

Those alloys most affected were the 195 and 356 alloys and modifications. As compared to typical mechanical properties for conventional permanent molded B195-T6 of 40,000 psi tensile, 26,000 psi yield, and 5 per cent elongation, properties of 53,000, 43,000, 3 per cent; and 49,000, 32,500, 7 per cent have been obtained. The mechanical properties of the Parlanti permanent molded A-356 approximates the published minimum values of 38,000: 28,000: 5, but the chilled shell molded properties of 44,400: 37,000: 10 are much higher.

No reason is apparent for this difference in properties between the permanent molded and chilled A356. Perhaps the design of the anodized aluminum mold was inadequate to effect maximum cooling rate. The aluminum chill in the shell evidently extracted the heat more rapidly in the critical area, thereby causing directional solidification.

It has been proposed that there is a size limit to the effective use of chills. This has been termed an infinite chill with a mass approximately equal to that of the casting. Table 4 shows comparative data for two different sized chills on alloy 195-10. Chill A had a volume approximately equal to that of the critical section (figure 4). Chill B's volume equals that of the casting. The difference in properties is attributed to the larger chill being capable of removing the heat from the casting much faster. There are no comparative values for the other alloys because the optimum size of chill was first determined and then applied exclusively in the other experiments.

Table 4—Comparison of Effect of Chill Size on Mechanical Properties of 195-10 Yokes

Chill	Heat Treatment*	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)
A†	1000-24, 350-16	38,000	33,700	2
B‡	1000-24, 360-14	53,000	43,000	3

*Heat Treatment-Solution Treatment Temperature (F). and time (hours), and Aging Temperature (F.) and time (hours)
A†—Critical Area
B‡—Casting

Table 5—The Effect of Varying Heat Treatment Times on Mechanical Properties of Anodized Aluminum Permanent Mold Cast 195-10

Heat Treatment*	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)
1000-12, 350-4	37,600	17,000	12
1000-12, 350-14	39,600	26,400	X
1000-24, 350-14	44,000	27,800	8
1000-24, 350-16	49,000	32,400	7

X—Broke Outside Gage Marks
*Heat Treatment-Solution Treatment Temperature (F). and time (hours), and Aging Temperature (F.) and time (hours)

Increase Aging Time

Because of the fine structure possible with permanent molding, it was thought that a shorter heat treatment would be possible. This supposition proved inaccurate, as shown in Table 5 for 195-10 alloy. An improvement in properties was realized with an increase in aging time. However, a more significant increase was realized by lengthening the solution treatment time.

Not all alloys could be improved by the modifications. The Al-Cu and Al-Si alloys responded most satisfactorily. The size of the chill was important. A chill of mass approximately equal to the casting was most effective.

Summary

Two aluminum castings have been developed with strengths substantially greater than with standard practice. This has been accomplished through rapid cooling of the castings by use of: anodized aluminum permanent molds; aluminum chills in shell molds; controlled chemistry to limit the impurities, especially iron, to an absolute minimum; and modified heat treatments, particularly in the solution treatment cycle, where extended times proved beneficial.

coke...carefully hand-picked...
to give you better melting in your cupola

Every foundryman knows how important *uniform coke size* is to a successful melting operation. Size bears a close relationship to carbon absorption, temperature rise, rate of combustion or reactivity, and to pressures.

That's why Semet-Solvay screens its five standard sizes of coke so carefully. And *after* screening, it is actually *hand-picked* to eliminate any oversized or off-quality pieces which might affect results in your cupola.

Yes, there's a size of Semet-Solvay coke just right for your foundry—it's uniform in size and quality for uniform results.

For the whole story, write today for our brand-new booklet, "The Advantages of Using Semet-Solvay Foundry Coke."

Allied Chemical

SEMET-SOLVAY DIVISION

Dept. 576-BI, 40 Rector Street,
New York 6, N. Y.

Circle No. 139, Pages 143-144

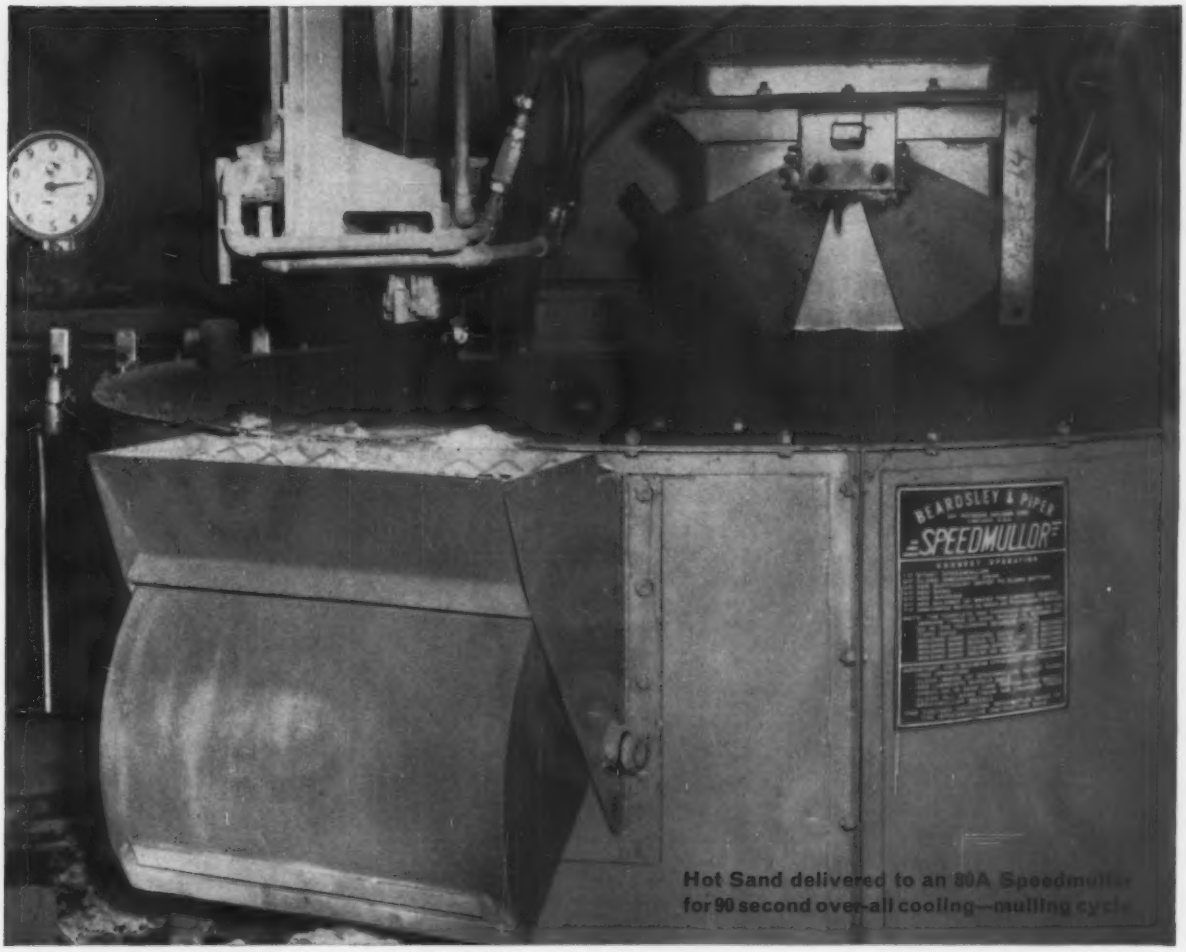
SPEEDMULLORS COOL HOT SAND

Hot Sand Cooled to Within 15°-25° of Room Temperature During Mulling In A 90 Second Cycle

High production—with resultant high metal to sand ratios—makes control of the hot sand problem an economic necessity. Quality castings can be produced only with properly cooled and mulled sand, and the logical place to control sand temperature is in the muller. Cooling is accomplished in the Speedmullor during the high-capacity mulling operation. Regardless of the high temperature of the sand entering the Speedmullor, it is cooled to a temperature where effective mulling can take place during the first 30 seconds of the mulling cycle. (Cooling to the same temperature in a conventional muller requires up to three minutes*). Additional cooling during the balance of the Speedmullor's 90 second cycle serves to bring the temperature of the sand to within 15 to 25° of room temperature. Competitive mullers cannot attain this temperature control without sacrificing capacity—and there is no excessive fines removal or costly loss of expensive binder additions during Speedmullor Cooling.

From B & P RESEARCH . . . the Only Complete Line of Mullers

Circle No. 140, Pages 143-144



Hot Sand delivered to an 80A Speedmullor for 90 second over-all cooling—mulling cycle

NO EXTERNAL COOLING DEVICES NEEDED—Additional space costs money, and any external cooling device requires additional space. Only Speedmullor cooling solves the hot sand problem with virtually no additional space. There is no comparison between installation cost, operating cost and maintenance cost of Speedmullor Cooling and external cooling devices or cooling elevators. *Speedmullor Cooling Costs Only One-Fourth As Much, Or Less.* External cooling devices normally require expensive additional equipment such as high capacity dust collectors and complex water addition systems. When cooling is accomplished in the Speedmullor the entire mulling and cooling installation is in one compact, low-cost package. Ask your B&P representative for additional Speedmullor facts. Let him show you how a Speedmullor can increase your productive efficiency economically and with no wasted space.

""The Problem Of Hot Molding Sands"* (*R. W. Heine—University of Wisconsin—and others.*)

BEARDSLEY & PIPER 2424 N. Cicero Ave., Chicago 39, Ill.
DIVISION OF PETTIBONE MULLIKEN CORP.

S. C. Massari

Castings Congress Papers

Fast microscopic test for ductile iron, heat treating die casting dies, industrial engineering in foundries are just three subjects covered in the Castings Congress Papers, this month. Other topics included in this exclusive feature of MODERN CASTINGS *are: handling molten metal for die casting, treating bentonite to influence its suspension, effect of casting temperature on aluminum test bars, and achieving maximum properties in* 85-5-5-5.

TECHNICAL HIGHLIGHTS

Achieving Maximum Properties in 85-5-5-5 ....p 55
Foundrymen are constantly faced with the question —"Given a casting of a certain design, what risering and chilling are necessary to provide soundness in specified sections?" Maximum mechanical properties and pressure tightness can only be achieved in bronze castings if the metal is sound. For 85-5-5-5 bronze a temperature gradient of 60 F per inch is needed to provide sufficient liquid flow to feed shrinkage during solidification. A castability test bar has been developed for determining thermal gradient needed to produce sound metal in any alloy.

Industrial Engineering in Foundries .....p 65
Over 377 replies were received to a questionnaire sent out to the foundry industry surveying incentive programs. Wage incentives, piece work, measured day work, and profit sharing are prevalent to varying degrees. It appears that the goal of most premium payment plans is to make it possible for workers to obtain an average performance of 120 to 130 per cent.

Heat Treating Die Casting Dies .....p 73
Here is a fundamental review prepared to guide busy die casters in their care and treatment of dies. Die steels are listed with their recommended uses. By selecting the right heat treatment, metal structures can first be made machinable then surface treated for maximum wear. Six basic rules are set down for achieving optimum die life and die casting quality.

Treating Bentonite to Influence its Suspension ..p 88
Many casting defects are related to bond strength of the sand mix. Adding salts of weak acids increases viscosity of clay suspensions. Wetting agents assist dispersion of bentonite in suspensions. Phosphates stabilize the clay structure to temperatures in excess of 2012 F. Viscosity can be increased or decreased without altering the pH.

Effect of Casting Temperature on Al Test Bars p 98
Test bar properties are meaningless unless the maximum temperature, time at temperature, and pouring temperature are standardized and carefully controlled. Most of the commercial aluminum casting alloys were studied and categorized according to how they were affected by: (1) high pouring temperatures (2) overheating or prolonged holding times. Mechanical properties are correlated with grain size which is determined by thermal history.

Handling Molten Metal for Die Casting .....p 110
In the highly mechanized and automated die casting industry molten metal handling has been traditionally manual. Now centrifugal pumps have been designed to operate indefinitely at 900 F in zinc die casting operations. Air pressure and vacuum systems have proven satisfactory for metering and delivering shots in the cold chamber process.

Fast Microscopic Test for Ductile Iron .....p 117
The AFS Ductile Iron Research Committee has developed a new practical tool for determining if each magnesium-inoculated ladle of iron will make satisfactory ductile iron castings. A test sample from each ladle is fractured, rough ground on a grinding wheel, and polished on a series of four silicon carbide abrasive pokers—the last being a 600 grit. Miscroscopic examination reveals the inherent modulizing tendency of the iron.

The AFS Castings Congress papers are the most authoritative technical information available to the metalcasting industry. Over 100 papers were prepared by close to 250 authors and presented at the 1960 Congress in Philadelphia, May 9-13. Papers receive preview publication in MODERN CASTINGS and then are bound into the annual volume of AFS TRANSACTIONS for permanent reference. All papers have been approved by the appropriate Program and Papers Committee of the sponsoring AFS Technical Division. They are then edited by AFS staff members C. R. McNeill and M. C. Hansen. Written discussion of these papers will be welcome.

SOLIDIFICATION CONDITIONS FOR MAXIMUM DENSITY AND MECHANICAL PROPERTIES IN 85-5-5-5 CASTINGS

Research Report
Brass & Bronze Division
Sponsored by
AFS Training & Research Institute
by R. A. Flinn and H. Kunsmann

ABSTRACT

A major factor affecting the mechanical properties and pressure tightness of bronze castings is their soundness. The data of this investigation indicate that for both plate and bar sections poured under a wide variety of chilling and risering conditions the chief factor determining the soundness of a section is the thermal gradient during solidification. Although the liquidus-solidus interval for 85-5-5-5 is about 220 F, a gradient of 60 F/in. provides sufficient liquid flow to feed shrinkage during solidification.

It is suggested that the specimen which has been developed and which provides a wide range of known thermal gradients can be applied to rate other alloys as a castability bar. In this way the thermal gradient needed to produce sound sections of a given alloy may be determined from a single test and the mold design can be approached with confidence.

INTRODUCTION — GENERAL PROBLEM

The engineer using copper-base castings is chiefly concerned with the mechanical properties, including pressure tightness, in critical sections of the casting. The cast tensile bar serves as an index of melt quality, but the actual properties of the casting may lie above or far below those of the test bar. The principal factor determining the extent of this vital difference between casting and test bar properties is the question of soundness.

It is generally understood that, given good melting and molding practices, the soundness will depend upon whether the shrinkage taking place during solidification is adequately fed by liquid metal. While risers and chills have been used for generations to cope with this shrinkage problem, there is still no general quantitative rule for their use in copper-base alloys.

The purpose of this investigation, therefore, has been to develop data leading to a solution of the general problem — *"Given a casting of a certain design, what risering and chilling are necessary to provide soundness in specified sections."* As a beginning, 85-5-5-5 bronze was chosen because of its industrial importance.

In previous reports[1,2] the techniques of this investigation have been described in detail. In the interest of conciseness, therefore, the critical experimental details have simply been indicated on the respective figures and graphs.

Feeding 2 x 2 x 12 in. Bar

To illustrate the crux of the problem, the feeding of a simple casting, a bar of 2 x 2 in. square cross-section and 12 in. long, may be reviewed. One way of attempting to obtain a sound casting in this design is to riser one end and chill the other, as shown in Fig. 1. As a measure of the success of this mold design, the leakage rate, the tensile strength and the density have been determined at different locations along the centerline of the bar. It is evident that the tensile strength, density and pressure tightness are low not only at the middle stations of the bar, but also toward the riser. (Of course, if in this casting only the region near the chilled end were critical, the casting would be satisfactory for service.)

If wedge chills are applied along the sides an improvement in all properties results, as shown in Fig. 2. It may seem to this point that only empirical manipulations of the mold design have been performed. However, if the actual conditions of freezing are measured by thermocouples in these different designs and correlated with the properties, a step toward solving the general problem has been made.

It may be helpful to review the conditions of solidification which are required for a sound casting. The ideal case, neglecting side wall effects, is shown in Fig. 3a. The metal begins to freeze at the chilled mold wall furthest from the riser, and as it freezes a supply of completely liquid metal is available at the interface to fill in the liquid-to-solid shrinkage. There is really no mushy zone containing liquid + solid, except insofar as the solid dendrites protrude into the liquid.

To carry this ideal case further, it may be assumed that the temperatures shown beneath the sketch are observed at this stage of freezing. The freezing point

R. A. FLINN is Prof. of Met. Engrg. in charge of Cast Metals Laboratory and H. KUNSMANN is Student, Dept. of Chemical and Met. Engrg., University of Michigan, Ann Arbor.

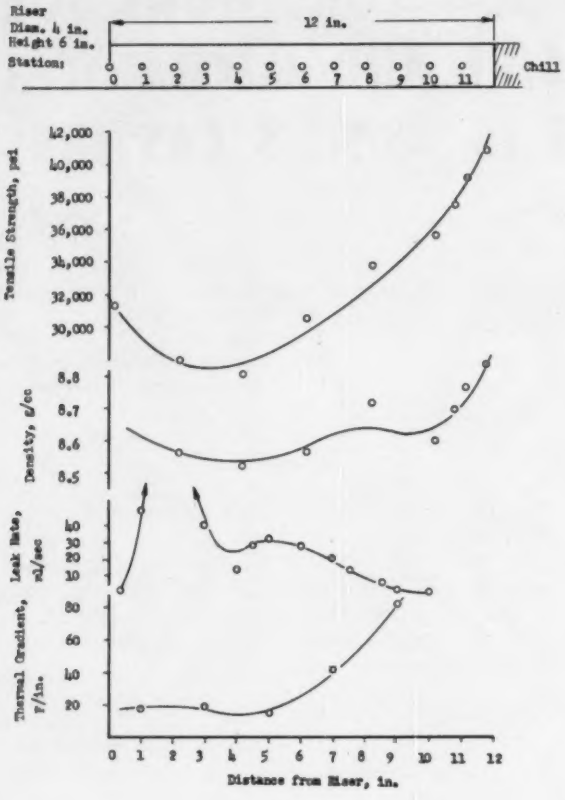


Fig. 1 — Mechanical properties of 85-5-5-5 test casting chilled at end, poured at 2025 F in dry sand.

then is about 1570 F, since liquid is present at hotter points (between the zero and 6 in. stations).

Temperature Distribution

85-5-5-5 bronze will begin to freeze upon reaching 1850 F but will not become completely solid until 1570 F.* If the same temperature distribution as in the ideal case is assumed, the structures on the mold cavity will be quite different (Fig. 5). Although there will still be solid metal extending from the mold wall, the rest of the mold will contain a mushy mixture of solid crystals plus liquid. In other words, instead of 100 per cent liquid at the face where final solidification is taking place, the material is practically solid.

For example at a point 1 in. closer to the riser from this face the temperature is 1580 F. Metal crystals have been forming here since this station reached a temperature of 1850 F (liquidus). The amount of solid is related** to the temperature of the station in the solidification range 1850-1570 F. Therefore, it would be predicted that the metal is 270/280 x 100 or over 95 per cent solid for one in. away from the final solidification front. It is improbable that all the voids forming at the interface can be filled under these conditions, and therefore lower density, shrinkage and reduced tensile strength are obtained.

On the other hand if the temperature distribution in the mold could be changed to the condition shown in Fig. 3c in which the temperature difference over one in. would be 220 F instead of 10 F, the solid would probably be sound because of the reduced path of travel of the liquid metal and the more open mushy zone.

There are three important points in these examples which will be developed further by actual and slightly more complex experimental data:

*neglecting the effect of Pb.
**this is not necessarily a linear relation as assumed here.

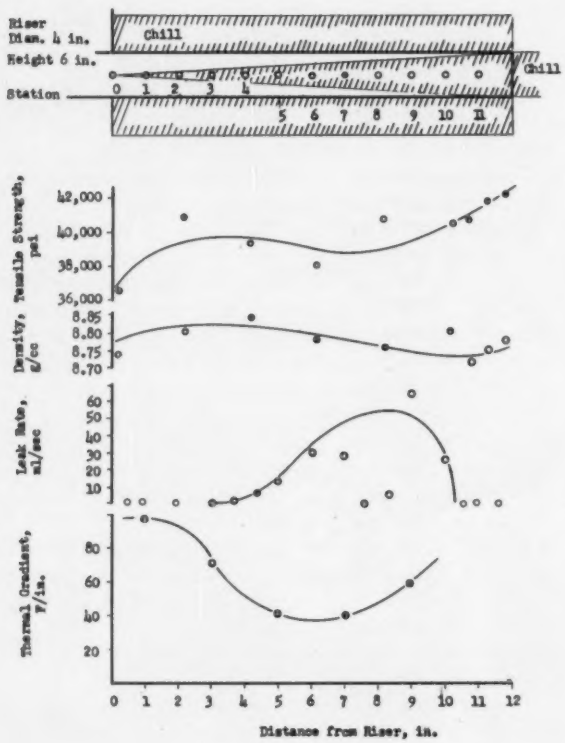


Fig. 2 — Mechanical properties of 85-5-5-5 test casting, chilled at end, poured at 2025 F in dry sand mold (heat 35-5). Modification-wedge chills on top, bottom and sides.

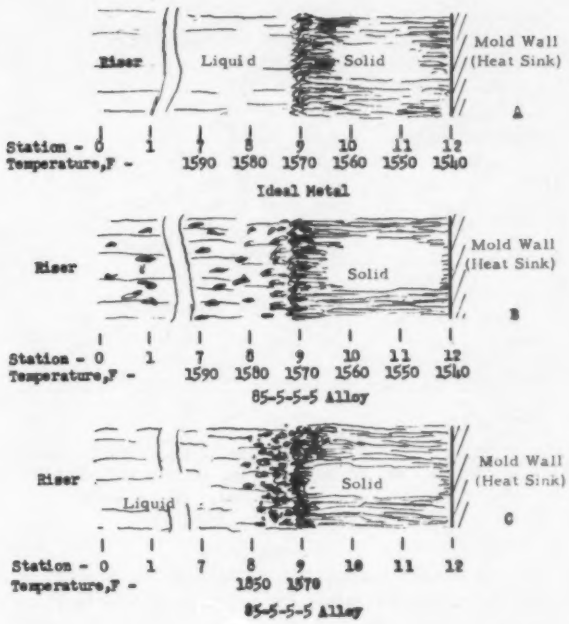


Fig. 3 — *Top* — in the ideal metal freeze begins at the chilled wall furthest from the riser and a supply of completely liquid metal is available at the interface to fill in the liquid-to-solid shrinkage. In 85-5-5-5 bronze begins at 1850 F, but it does not become completely solid until 1570 F. Solid metal will extend from the mold wall, but the rest of the mold will contain a mushy mixture of solid plus liquid, i.e. the material will be practically solid.

1) The use of risers and chills produces directional solidification, but this is not a guarantee of soundness.
2) The temperature distribution needed to produce soundness will vary with different alloys which have shorter or longer freezing ranges.
3) The time at which the temperature distribution is important at a given station is when final solidification is taking place at that station.

Soundness During Solidification

It is important next to determine the temperature distribution needed for soundness during solidification of 85-5-5-5. In the case in Fig. 3c, it was stated that if the temperature was 220 F higher one in. away from the solid the casting would probably be sound. However, there is really no basic quantitative reason for this assumption. It is necessary at present to develop experimental data for each alloy to determine the temperature distribution needed for soundness.

The simple bar casting which was described earlier provides exactly this type of information. If fine butt welded thermocouples inserted in fused silica protection tubes are placed at different centerline stations, a continuous record of the temperature distribution can be obtained for a given mold design. This can then be correlated with the properties of the casting.

In discussing these temperature records it is necessary to employ the concept of thermal gradient in place of the general term temperature distribution.

The average foundryman is quite familiar with other gradients. For example, in installing a concrete floor which is to drain rapidly, the contractor might be asked to provide a slope of 6 in. over a 10 ft slab. This is a gradient (or slope) of 0.6 in./ft. In similar fashion, in the bar shown in Fig. 3a, the temperature difference between the ends is 120 F and the gradient is therefore 10 F/in.

If in the case of the concrete floor the slope was not even, the overall gradient would not describe the condition accurately. Suppose that in the first 5 ft across the floor the elevation dropped 6 in. and the remaining 5 ft were level. The gradient would be 1.2 in./ft for the first region and zero for the remainder. Similarly, in the case of the bar casting, it would be expected that the thermal gradients near the riser and near the chill will be greater than in the long center portion of the bar.

Thermal Gradient Determination

The steps in determining the thermal gradient are relatively simple. First, the temperature at each point in the casting is plotted as a function of time [Fig. 4 (Fig. 5 from 1959 paper)]. The gradient at each station will vary with time. At two moments there will be no gradient—when the entire casting is cold, and when the casting has just been poured, if the mold is filled rapidly. The thermal gradient develops because the end away from the riser transfers heat to the mold wall at a greater rate than the risered end.

The time at which the thermal gradient is most important in determining the soundness at a given station is when that station is undergoing final solidification. To determine this gradient, the simplest procedure is to read the temperature of the nearest station toward the riser and divide by the distance. In Fig. 3c the station one in. away is 220 F hotter when station 9 is solidifying (at 1570 F). The gradient is therefore 220 F/in.*

Figures 1 and 2 show that the difference between the two castings is related to the thermal gradient. The unsound, low strength region in the center of the first bar is accompanied by a low thermal gradient, while the second bar has a high gradient in this region.

The data from this one bar go far beyond the explanation of the properties of this simple casting. These empirical data tell the general conditions nec-

*More strictly the gradient, dT/dx, is the tangent to the isochromous temperature distribution curve as explained in reference 2 but this is a good approximation.

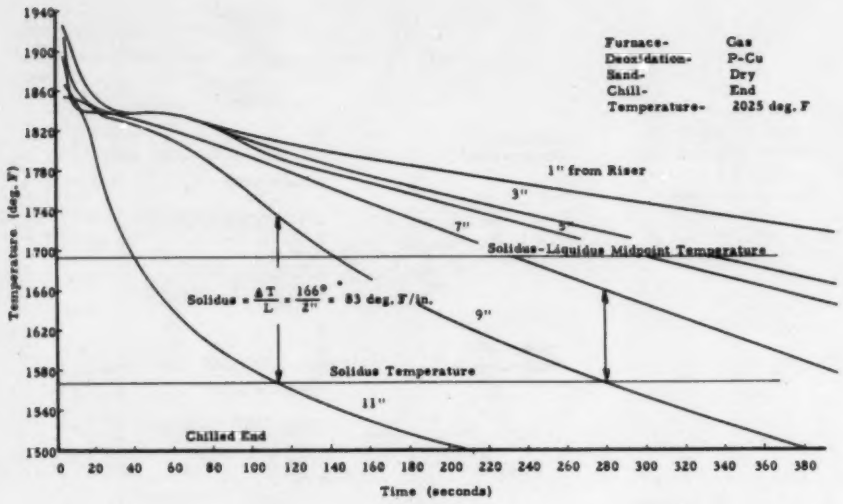


Fig. 4 — Typical cooling curves, secant method. H36. 2 in. bar.

essary to obtain acceptable soundness in castings of this type. Note that when the gradient is over 60 F/in. during the solidification of a given region it is pressure tight, high strength and of maximum density. This means that it is not necessary to have 100 per cent liquid close to a region undergoing final solidification. There is apparently sufficient mobility in the mushy region for liquid metal transport when the gradient is 60 F/in. or over.

To verify this theory a melt of 85-5-5-5 was tested for fluidity after solidification had begun in the crucible. Uniform temperature was maintained by gentle induction stirring. It was possible to suck the liquid + solid mixture for several inches into ¼-in. diameter tubes even when the temperature was 150 F below the liquidus (precautions were taken to prevent supercooling effects).

Theory Application

To test the general application of the thermal gradient theory a variety of bar and plate sections have been cast and tested. These simple shapes were selected on the premise that even a complex casting can be considered as made up of a number of simple geometric shapes, and the proper data may then be applied.

The following mold designs have been employed:

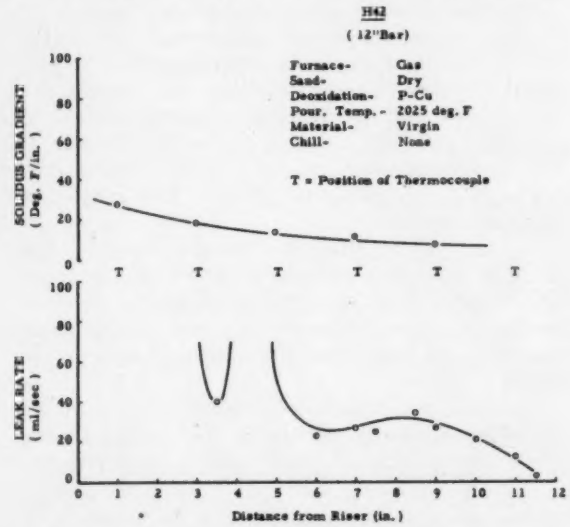


Fig. 5 — Curve for 12 in. bar from heat H42.

Bars

A) 2 x 2 x 12 in. (dry sand except as noted).
Modifications:
1) end chill, riser (standard bar).
2) unchilled, risered (also unchilled, unrisered).
3) end chill, variations in riser size.
4) exothermic risers.
5) wedge chills at different locations.

B) Variations in bar length (not cross-section).
1) 9 in. long end chill.
2) 9 in. long wedge chill.
3) 6 in. long end chill.
4) 6 in. long wedge chill.
5) 3 in. long no chill.

C) Variations in bar cross-section (all bars 12 in. long).
1) 1½-in. end chill.
2) 1 in. end chill.
3) ¾-in. end chill.
4) Misc. rectangular cross-sections.

Plates

A) 6 x 6 x 1 in.
1) no chills.
2) end chills at center of end.
3) wedge and end chills.
4) complete wedge and end chills.
5) contour chills.

B) 6 x 6 x 1 in.
1) no chills.
2) end chill.

C) 4 x 4 x 1 in.
1) end chill.

D) 4 x 4 x ½-in.
1) no chills.

The data for a number of the specimens listed have been described in previous reports. These data are not repeated in detail here except where direct comparison with recent data is particularly valuable, Figs. 5-23.

In reviewing these results, it will be noted that in bar castings of 1½-in. cross-section and over, and in

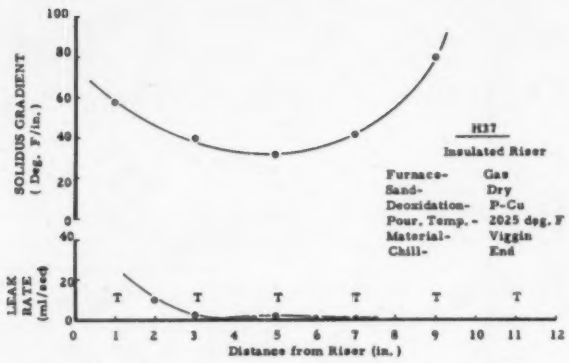


Fig. 6 — Curve for bar with insulated riser from heat H37.

1 in. plates, a minimum gradient of 60 F/in. is necessary for pressure tightness. However, a lower gradient or no gradient is required in light bar and plate sections for pressure tightness. This does not, however, mean that these light sections are sound. Leakage is only measurable in the pressure test when continuous voids over 0.031 in. long are present through the specimen. (The specimen is a $\frac{1}{32}$-in. thick plate cut horizontally at the centerline of the bar.) When solidification is rapid, as in light sections, the shrinkage cavities are finer.

With these qualifications in mind the data of the table may be reviewed.

DISCUSSION

The data to be discussed may be divided into two principal groups—bar sections and plate sections, as listed in the Summary (table).

Bar Sections (Figs. 5-14)

2 x 2 x 12 in. bars. In scanning the summary data, the importance of chilling and the possibility of combined chilling and risering effects becomes apparent. An unchilled, risered bar exhibits a maximum gradient of 28 F/in. and is unsound at the centerline throughout its length. The application of an end chill produces a sound region extending over 4 in. from the chill. Variations in riser size and the use of exothermic risers change the thermal gradient but do not raise the gradient enough, and the first 8 in. of the bar are still unsound.

Wedge chills along all sides, combined with the end chills, produce satisfactory gradients for a larger portion of the bar. It is possible that a combination of exothermic or insulated risers and end chills might produce a completely sound bar. The purpose of the experiment however was to develop a variety of thermal gradients and correlate these with leak rate. A partially sound bar is more valuable for this objective.

Variations in Bar Length. If the bar is shortened, the temperature difference between the ends obtainable by chilling and risering will still remain the same. Therefore, the average gradient will increase, and it is simpler to produce a sound bar. End chilling alone is not sufficient, and the first 5 in. of the

SUMMARY OF BAR DATA

(numbers in parentheses are heat nos.)

	Pressure Tight Region (in. from riser)	Thermal Gradient at Solidus in Pressure Tight Regions
2 x 2 x 12 in. bars		
1. end chill, riser *(standard bar)* (H36-1)	7.5 in. - 12 in.	60 F/in.
2. unchilled risered (H42-1), Fig. 5	none	(28 F/in. max.) (not sound)
3. end chill, variations in riser size; 37% larger to 44% smaller	7.5 in. - 12 in.	60 F/in.
4. exothermic risers (H37), Fig. 6	7-8 in. - 12 in.	60 F/in.
5. wedge chills at diff. locations	0-4, 10-12	70-110 F/in., 60 F/in.
Variations in Bar Length (not cross-section)		
1. 9 in. long end chill (H51), Fig. 8	5.5 - 9	65 F/in.
2. 9 in. long, wedge chills, Fig. 9	0 - 9	60-120 F/in.
3. 6 in. long, end chill (H52), Fig. 10	3 - 6	65-50 F/in.
4. 6 in. long, wedge chill, Fig. 11	0 - 6	120 F/in.
5. 3 in. long no chill (H53), Fig. 7	0 - 6 slight leakage	8-20 F/in.) (not sound)
Variations in Cross-Section (12 in. long bars)		
1. 1½-in. end chill H56, Fig. 12	6 - 12	40-120 F/in.
2. 1 in. end chill H56, Fig. 13	0 - 12	10-120 F/in.
3. ¾-in. end chill H55, Fig. 14	0 - 12 slight leak	8-40 F/in.
4. 2 x ½-in. cross-section	0 - 12 slight leak	5-40 F/in.
6 x 6 x 1 in. plates		
1. no chills (H40), Fig. 15	0	10-40 F/in.
2. end chills at center of end (H45), Fig. 16	3.5 - 6 in.	70-140 F/in.
3. wedge and end chills (H46), Fig. 17	0 - 6 slight leak in center	30-140 F/in.
4. complete wedge and end chills (H47), Fig. 18	0 - 1.5, 5 - 6	70-120 F/in.
5. contour chills (H50), Fig. 19	0 - 2, 4.5 - 6	60-110 F/in.
4 x 4 x 1 in. plate		
1. end chills (H57), Fig. 22	0 - 6	100-280 F/in.
6 x 6 x ½-in. plates		
1. no chills (H58)	0 - 6 slight leakage	20-110 F/in.
2. end chill (H57), Fig. 21	0 - 6	100-150 F/in.
4 x 4 x ½-in. plate		
1. no chills (H45), Fig. 23	0 - 6	50-100 F/in.

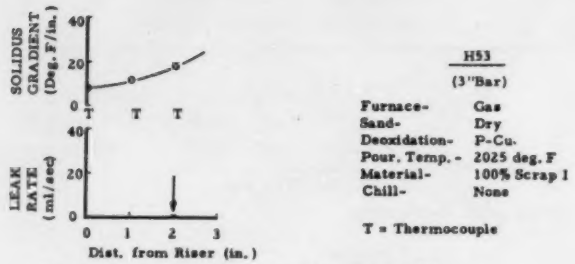


Fig. 7 — Curve for 3 in. bar from heat 53.

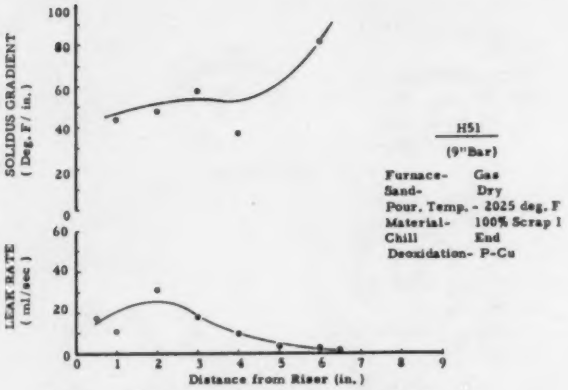


Fig. 8 — Curve for 9 in. bar from heat H51.

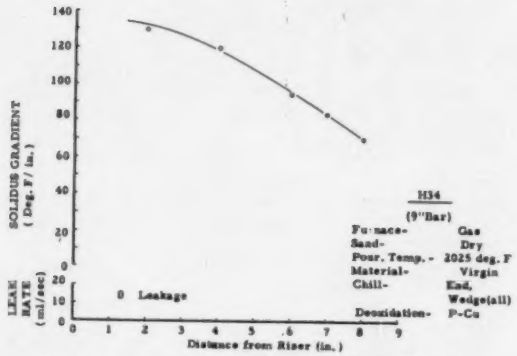


Fig. 9 — Curve for 9 in. bar from heat H34.

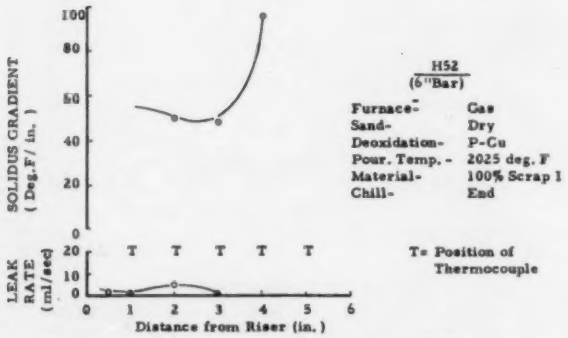


Fig. 10 — Curve for 6 in. bar from heat H52.

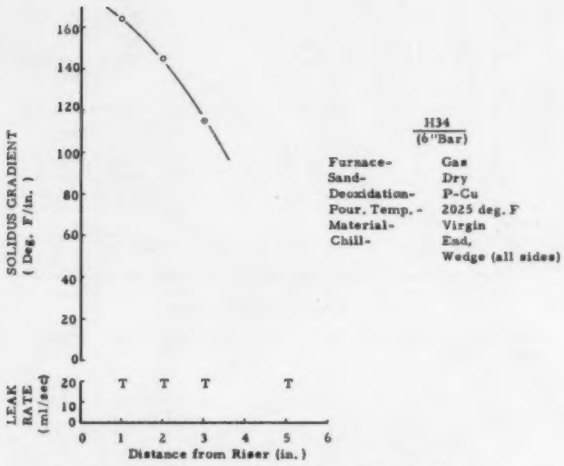


Fig. 11 — Curve for 6 in. bar from heat H34.

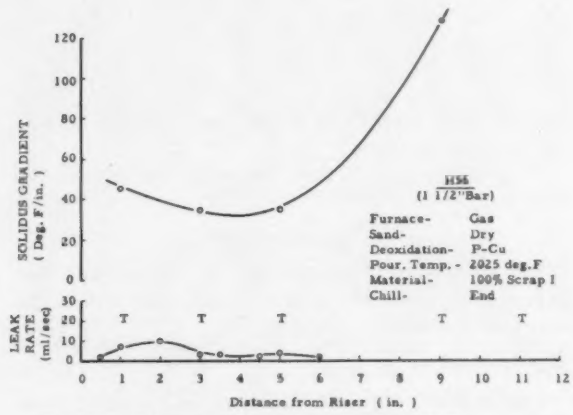


Fig. 12 — Curve for 1½-in. bar from heat H56.

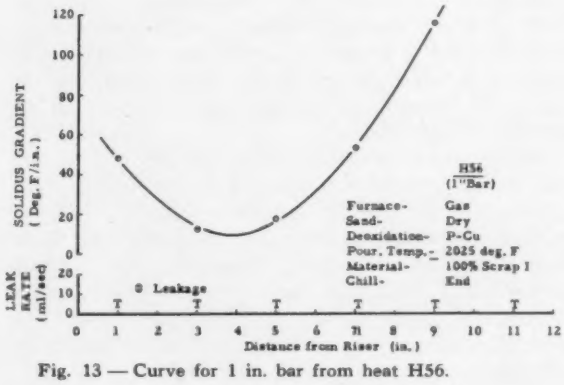


Fig. 13 — Curve for 1 in. bar from heat H56.

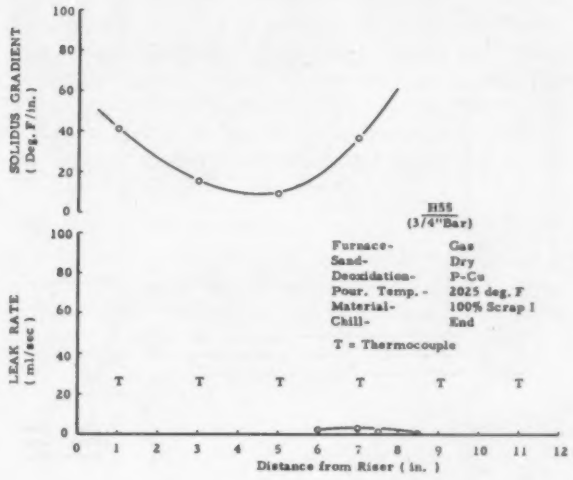


Fig. 14 — Curve for ¾-in. bar from heat H55.

bar nearer the riser are still unsound. By employing wedge chills to distribute the gradient more evenly a minimum gradient of 60 F/in. is reached, and the entire bar is sound. Similar effects are noted for the 6 in. long bar—even in this case the wedge chills are required for complete soundness.

The 3 in. long bar provides a limiting case. Although the gradient of 60 F/in. is not attained, only slight leakage was noted. It is suspected that the nearness of the large high riser to the stubby 3 in. section provided pressure effects in driving liquid into the bar. Also while the section near the riser was unsound in all the longer bars, it must be remembered that some liquid was drained from this section in these cases by the remote sections of the casting. In the case of the 3 in. bar, no metal was drawn off and all the liquid available from the riser during final solidification could be used.

Variations in Cross-Section. As the cross-section decreased from 2 to ¾-in., a longer region of the bar was pressure tight. At first glance this seems contrary to solidification principles because as the cross-section narrows it would be expected that the effect of the chill would be reduced. Two other points are apparently more important. The more rapid solidification will produce a finer dispersion of voids since the metal crystals will be smaller. Even though the total void volume of an unfed region will be the same, if the voids are smaller, a 0.031 in. thick pressure specimen may be leakproof.

In the center of the 1 in. bar, for example, a density measurement of 8.69 g/cc was obtained compared to the value of 8.80-8.85 g/cc for sound material. It would be expected that the tensile strength of this region with fine voids would also be lower than for sound material. For similar reasons, the 2 x ½-in. cross-section was practically sound despite low thermal gradients.

Plate Data (Figs. 15-23)

6 x 6 x 1 in. plates. A one in. plate section is approximately comparable in freezing rate to a 2 in. bar because of the greater surface to volume ratio of a bar. The unchilled plate therefore understandably shows leakage all along the centerline and a thermal gradient of 10-40 F/in., comparable to the bar. End chilling produces a region of 2.5 in. of sound metal, and a gradient of 70-140 F/in. is noted in the sound region. A rather extensive variety of end, wedge and contour chills was tried in heats 46, 47 and 50 and practically leak-free specimens were obtained.

Figures 15-19 should be consulted for details since the solidification pattern is far more complex in some cases than for the bars. It is evident in several instances that the development of a good gradient by chilling one portion led to an inferior gradient in other sections. In this case the voids were changed in position, not eliminated. For example, the metal near any of the lower regions of a flat plate is normally sound. However, if chills are placed over the center, this region may solidify before the corners and shut off the supply of feed metal to the corners.

4 x 4 x 1 in. plate. When the dimensions of the 1-in. plate are changed to 4 x 4 x 4 in., a sound casting

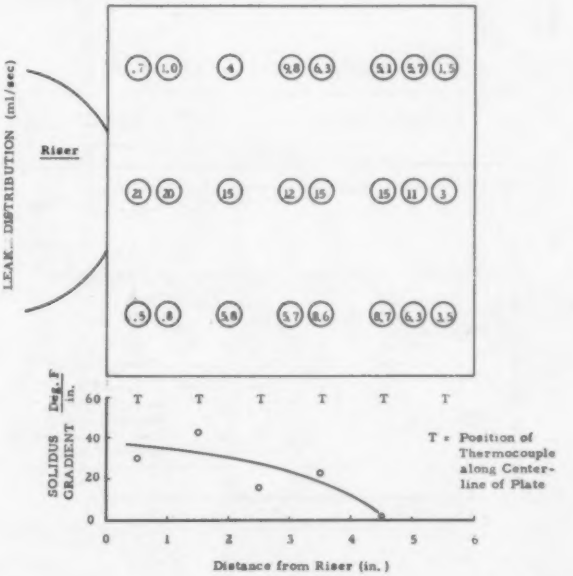

LEAK DISTRIBUTION (ml/sec)
Riser
.7 1.0 4 9.8 6.3 5.1 5.7 1.5
21 20 15 12 15 15 11 3
.5 .8 5.8 5.7 8.6 8.7 6.3 3.5
SOLIDUS GRADIENT Deg. F/in.
T = Position of Thermocouple along Centerline of Plate
Distance from Riser (in.)

Fig. 15 — 6 x 6 x 1 in. plate from heat H40. Gas furnace, dry sand, P-Cu deoxidation, 2025 F pouring temperature, virgin material and no chill.

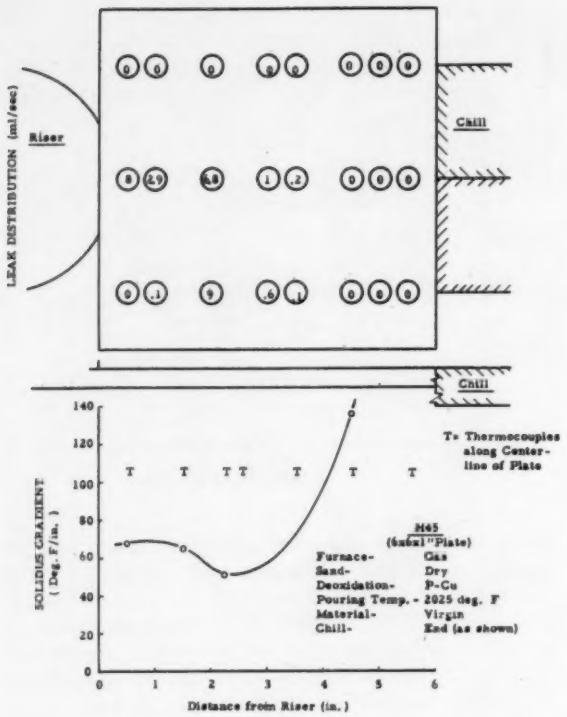


Fig. 16 — 6 x 6 x 1 in. plate from heat H45.

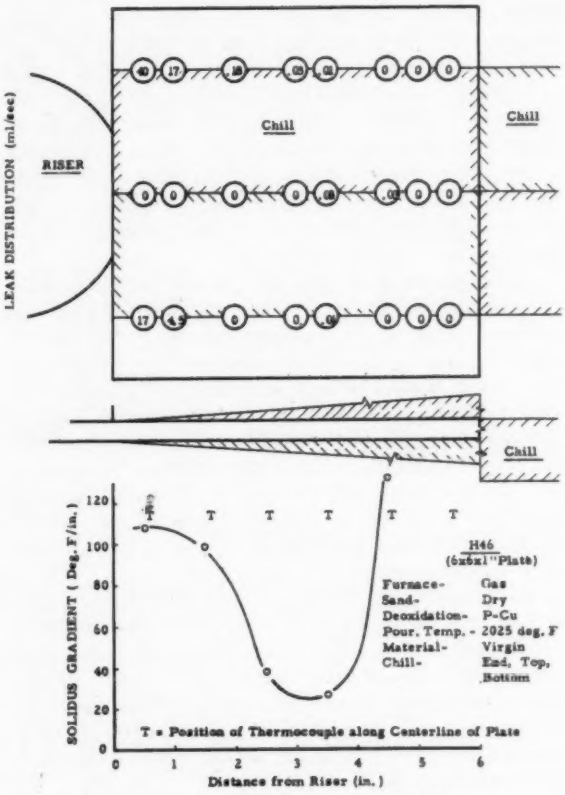


Fig. 17 — 6 x 6 x 1 in. plate from heat H46.

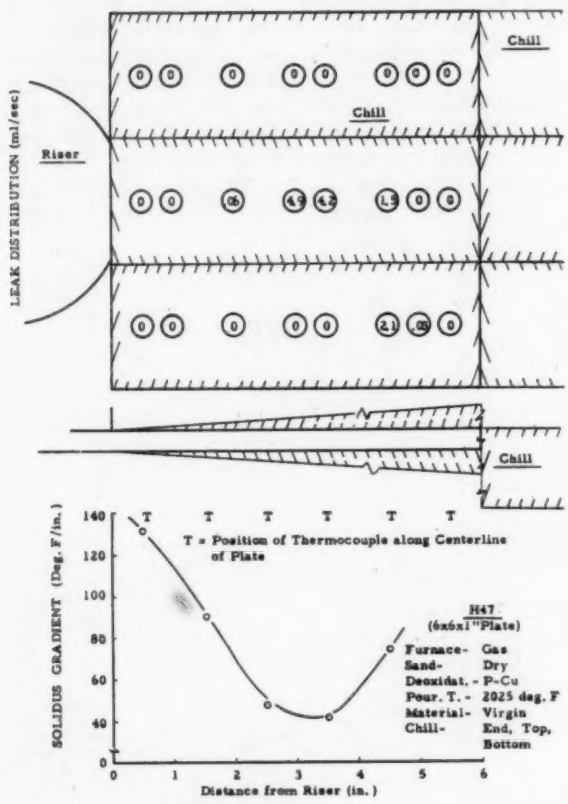


Fig. 18 — 6 x 6 x 1 in. plate from heat H47.

is obtained simply by end chilling. This may seem unusual because only 2.5 in. of the 6 x 6 in. plate were sound, not 4 in. However, it should be kept in mind that the volume has been reduced over two times and the feed demand to the sides of the centerline has been reduced. The gradient throughout the plate is well over the minimum, being 100-280 F/in.

6 x 6 x ½-in. and 4 x 4 x ½-in. plates. The ½-in. plates are analogous in some ways to the 1 in. bar sections but show surprisingly high thermal gradients. Even without chills these plates are, in the main, sound. Although pouring conditions were kept constant throughout all these experiments, the gradient developed during metal flow would be greater in a thin plate than in a heavier casting. The molds were tilted uphill away from the riser and rather uniformly colder metal would reach the region farther from the riser. It is suggested that the combination of the thermal gradient and finer void dispersion led to pressure tightness in these cases.

Other Variables Effects

To preserve continuity in the foregoing discussion no reference was made to other variables which were rather extensively investigated before undertaking the

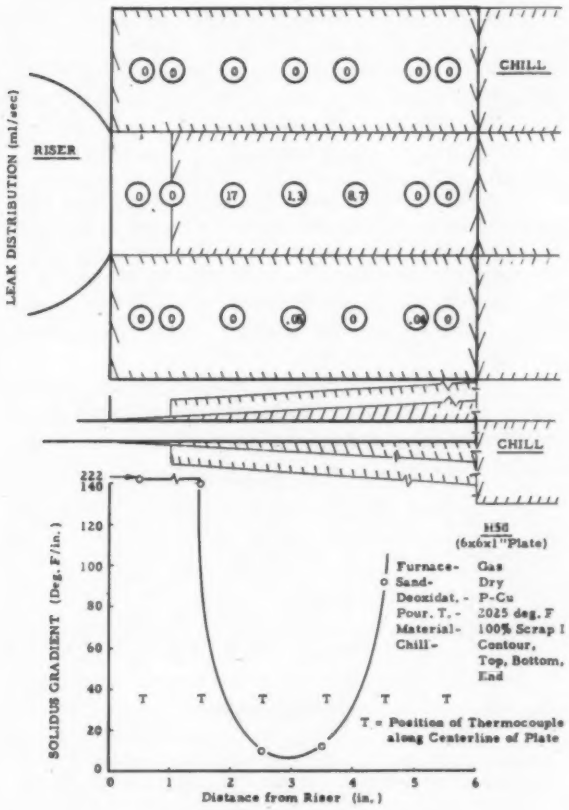
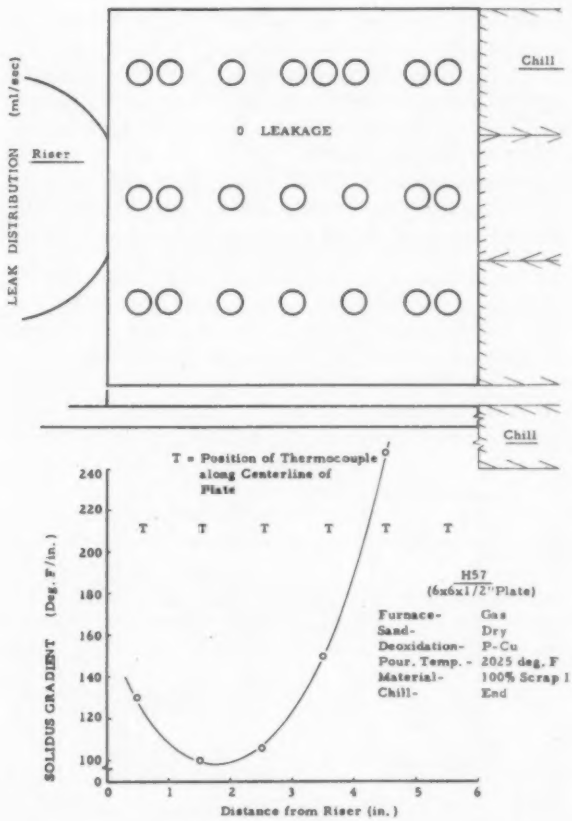


Fig. 20 — 6 x 6 x ½-in. plate from heat H57.

Fig. 19 — 6 x 6 x 1 in. plate from heat H50.



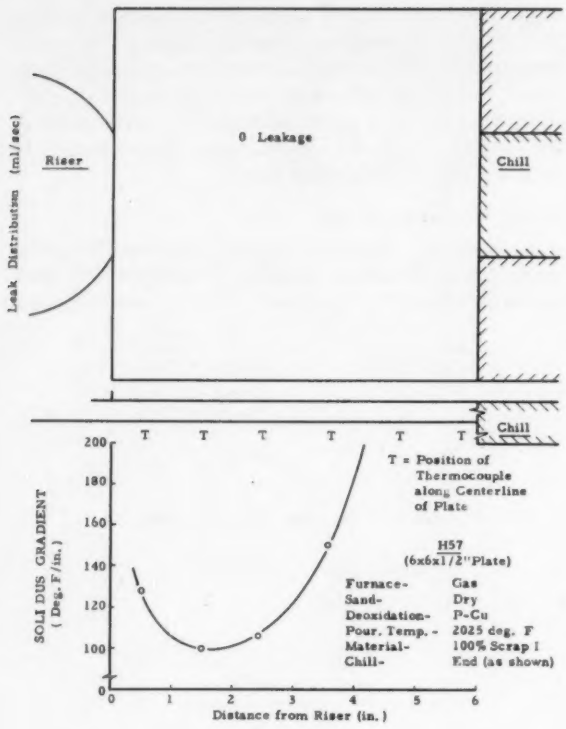


Fig. 21 — 6 x 6 x ½-in. plate from heat H57.

work just described. In previous reports[1,2] the effects of pouring temperature, mold material and deoxidation practice received attention. The principal effects of these variables are upon the gas content of the metal which of course can lead to voids by an entirely different mechanism.

In previous work it was found that high pouring temperatures (2200-2400 F) led to gas porosity, presumably because of the longer time for liquid metal-mold reaction. This produced dissolved gases which precipitated upon freezing. The use of green sand, particularly of high moisture content, led to greater gas porosity. As would be expected, omission of phosphor copper as a deoxidant also led to porosity. For these reasons all of the specimens described in this work were crucible melted with an oxidizing flame, deoxidized with 20 g. P-Cu per 100 lb metal and poured at 2025 F in dry sand molds.

CONCLUSIONS

To produce maximum density, strength and pressure tightness in 85-5-5-5 bronze a thermal gradient of 60 F/in. is required. This can be obtained by a combination of risering and chilling, as illustrated in the data. Light sections may be pressure tight with lower gradients because of finely dispersed shrinkage cavities.

The 12 x 2 x 2 in. casting should provide a generally useful test for determining the thermal gradient needed for soundness in other alloys.

ACKNOWLEDGMENT

The authors wish to acknowledge the thoughtful and extremely helpful support of the members of the AFS Brass and Bronze Div. Rsch. Committee and that of the AFS Training and Research Institute, Messrs. F. L. Riddell, R. B. Fischer, H. F. Bishop, R. A. Colton, G. J. LeBrasse, R. W. Ruddle, E. F. Tibbetts, C. W. Ward, Jr.

REFERENCES

1. R. A. Flinn and P. K. Trojan, "Pressure Tightness in 85-5-5-5 Bronze," AFS TRANSACTIONS, *vol. 64*, p. 339 (1956).
2. R. A. Flinn and C. R. Mielke, "Relationships of Thermal Gradients during Solidification to Pressure Tightness of 85-5-5-5 Bronze," AFS TRANSACTIONS, *vol. 67*, p. 385 (1959).

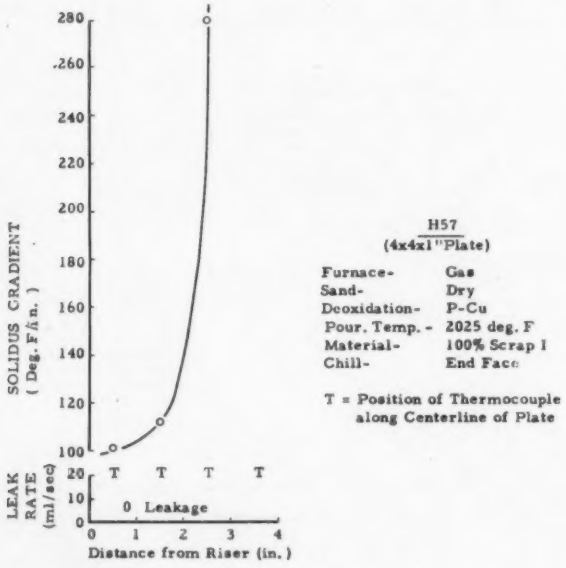


Fig. 22 — 4 x 4 x 1 in. plate from heat H57.

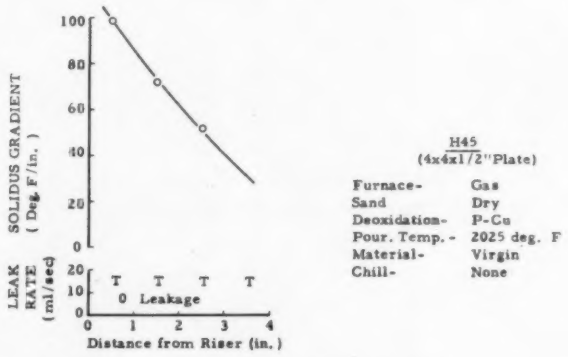


Fig. 23 — 4 x 4 x ½-in. plate from heat H45.

INDUSTRIAL ENGINEERING IN THE FOUNDRY INDUSTRY

A Survey

by M. T. Sell

ABSTRACT

The results of a questionnaire sent out to foundries regarding incentives are given by the author. The type of wage payment plans of various foundries, premium earnings, indirect labor operations, control methods, and various other items are covered in the results. The findings of the questionnaire are presented in chart form. Industrial engineering department duties as performed by the answering plants are also presented.

INTRODUCTION

The Industrial Engineering and Cost Committee has received numerous letters from foundries, not only in the United States but also from foreign countries, relating to questions concerning wage incentives, industrial engineering and costs.

Most of the questions asked could only be answered if one were familiar with the plant, its operations and the personnel involved. The committee endeavors to answer all questions as accurately as possible by referring the party to the well known AFS publication TIME AND MOTION STUDY FOR THE FOUNDRY. If the question is not covered in the AFS publication, they are referred to some company where a like problem has been solved. In many cases it is suggested they contact some reputable consultant to help them.

It was the opinion of the committee that a questionnaire, sent to all AFS member foundries would, when analyzed, possibly answer many questions and be of some help to the industry. While it was impossible to include every question that might arise, or to get an appreciable amount of detail, it is believed that the questionnaire as it was analyzed would be of assistance in solving some of the problems.

The incentive questionnaire received the best response of any which has been sent out by AFS headquarters. There were 377 responses from companies finding it possible to reply. The replies came from companies in at least six known foreign countries.

METHOD OF ANALYSIS

In order to analyze the questionnaires, they were first divided into groups according to the number of employees which, of course, indicates the size of the plant. As shown on Fig. 1, they were divided into five groups, 0 to 50, 51 to 100, 101 to 200, 201 to 300 and over 300 employees, with 67, 79, 70, 52 and 109 responses, respectively.

These groups were further analyzed, Fig. 1, to determine the number of plants within each group which classed themselves as mechanized, semi-mechanized, production, manual, jobbing or a combination of one or more of the categories. The captive foundries were noted to ascertain if they followed any given pattern relating to any of the questions asked.

It will be noted that the semi-mechanized and jobbing shops carry a higher percentage of the total in all groups except the largest shops where mechanization appears to be more predominant. It appears that the percentage of manual operated plants becomes less as the size of the plant increases as do those doing jobbing work.

WAGE PAYMENT COMPARISON

Comparing the type wage payment with the type of operation in Fig. 2, indicates that the day-work shop still prevails in the foundry industry, with the largest percentage appearing in the largest group of over 300 employees. The fact that there are more captive plants in this group, with many of them in the automotive field, may be part of the reason for the larger number of day-work shops.

The percentage of plants operating on a piece-work plan varies little within the groups, with the exception of the 100 to 200 employee group, which indicates 8 to 10 per cent more.

"Wage Incentive" type of operation has its greatest use in the 50 to 100 employee group, with all groups except those with over 300 employees showing a lesser percentage. This may again be due to the large number of the captive foundries found among the larger plants.

"Measured Day Work" is prevalent in but few foundries in any of the five groups, which would tend to dispel any ideas that this type of wage payment is replacing piece work or wage incentives.

The "Profit Sharing" type of wage payment may be found in all categories with the highest percentage

M. T. SELL is Indus. Engr., Sterling Foundry Co., Wellington, Ohio.

GROUP 1	6	Mechanized
	29	Semi-Mechanized
Up to 50 Employees	14	Production
67 Responses	19	Manual
	39	Jobbing
	16	Captive
GROUP 2	7	Mechanized
	45	Semi-Mechanized
50 to 100 Employees	11	Production
79 Responses	21	Manual
	52	Jobbing
	27	Captive
GROUP 3	15	Mechanized
	46	Semi-Mechanized
100 to 200 Employees	22	Production
70 Responses	12	Manual
	46	Jobbing
	18	Captive
GROUP 4	21	Mechanized
	28	Semi-Mechanized
200 to 300 Employees	15	Production
52 Responses	8	Manual
	30	Jobbing
	15	Captive
GROUP 5	54	Mechanized
	46	Semi-Mechanized
Over 300 Employees	43	Production
109 Responses	14	Manual
	51	Jobbing
	39	Captive

377 Responses	103	Mechanized
	194	Semi-Mechanized
	105	Production
	74	Manual
	218	Jobbing
	115	Captive

Fig. 1 — Response to questionnaire.

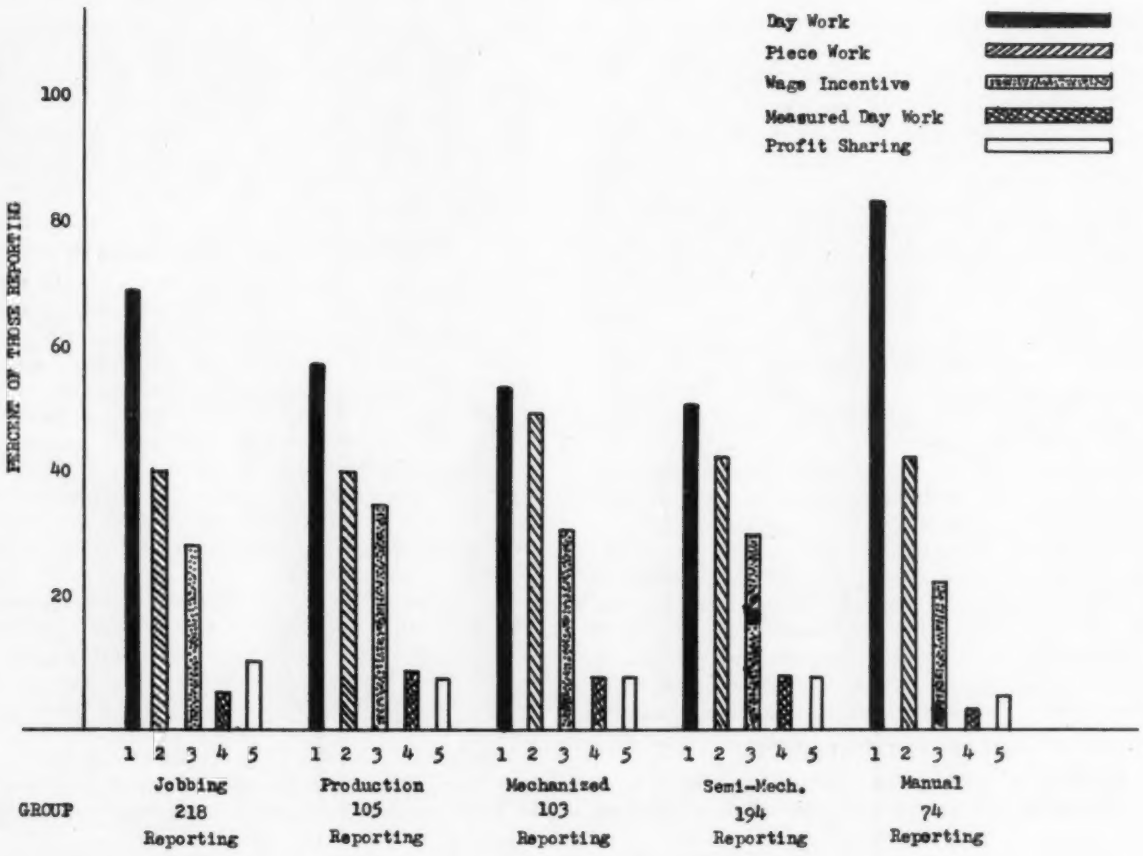


Fig. 2 — Type of operation.

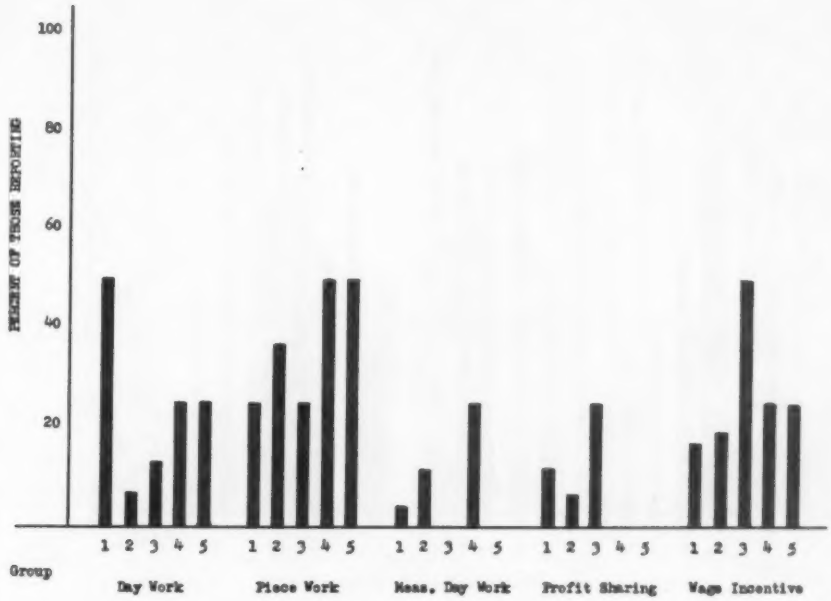


Fig. 3 — Type of wage payment, non-ferrous foundries only.

in the 0-50 employee group. A higher percentage is perhaps found in this group because of the cost of installing, operating and administering a profit sharing plan is much less than other plans which reward the employee for extra work.

NON-FERROUS FOUNDRIES

Since there was a goodly number of non-ferrous foundries who responded, Fig. 3 was made to indicate the type of wage payments prevailing in the various groups. As can readily be observed, piece work and wage incentives prevail. While piece-work plans indicate the highest percentage, many responses indicated that they are in the process of changing from piece work to a wage incentive plan.

Measured day work and profit sharing plans would appear to be not too popular in the non-ferrous foundries.

The question "should we employ outside consultants to install an incentive system, or should we use our present company personnel" is the one most often asked of this committee. Figure 4 indicates how those having some form of premium payment have made their installations. Although the chart shows that the larger plants used company trained personnel, about 50 per cent of the smaller plants did likewise. While the larger plants have the greater number of qualified personnel for such work, it might have been supposed that the percentage of small foundries using their own personnel would have been much smaller.

One reason for this is because those smaller plants which are captive foundries make use of the trained personnel of the parent organization for this work, and they are therefore not termed outside consultants. As indicated on the chart, an average of about 40 per

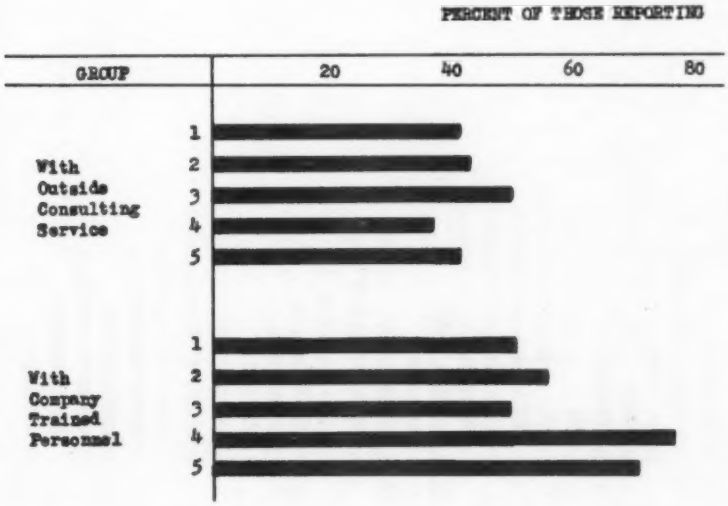


Fig. 4 — Installation of system.

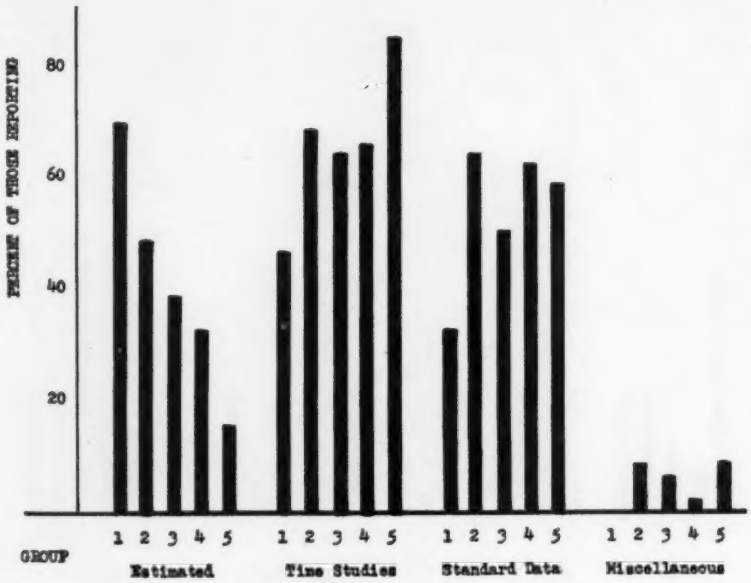


Fig. 5 — Method of determining time allowances.

cent of all foundries used outside consultants to make their installations.

The "Method of Determining the Time Allowances" is another question often asked of AFS and the committee. Figure 5 shows the estimated method to be most prevalent in the smaller plant where personnel is limited and time will not permit the use of time study or other technical methods. The time-study method is the most common, especially in the over 300 employee group where more personnel are available. The chart indicates that a fair percentage of the plants are using the standard data method, and many responses indicated that they are presently changing over to this method of determining time allowances.

"Miscellaneous" methods reported were amendments to the original estimates, amendments to original studies, M.T.M. in conjunction with time studies and work sampling.

PREMIUM PAYMENT PLAN

The question "How many employees should be entitled to premium earnings" has perhaps been asked by management, and discussed at the bargaining sessions many times at those companies having a premium payment plan. As indicated on Fig. 6, the largest group of plants have 76 to 100 per cent employee coverage. This can be attributed to the number of foundries changing over to standard hour plans, thus providing the tools by which much of the indirect labor can be placed on an incentive or premium plan. Profit sharing plans normally cover 100 per cent of the employees, and thus tend to increase the number of plants falling in this category.

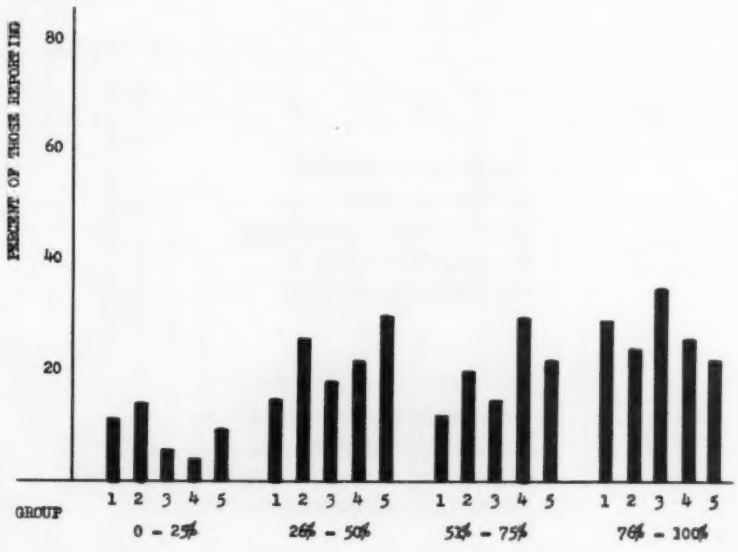


Fig. 6 — Employees covered by premium earnings.

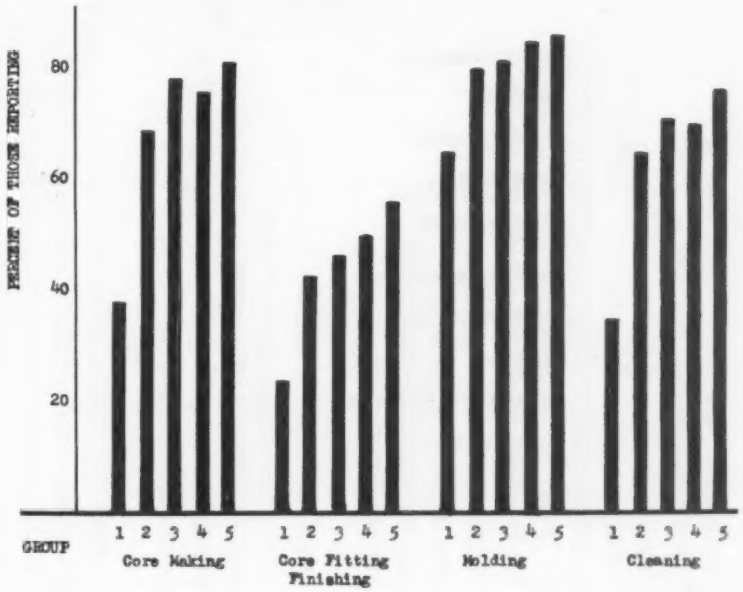


Fig. 7 — Standard/piece work coverage.

Breaking employee coverage down still further, Fig. 7 shows that coremaking and molding have the greatest coverage among the direct labor jobs. In the comparisons of the direct labor categories of coremaking, core fitting, molding and cleaning, the larger plants indicated the highest per cent of coverage. This can perhaps be attributed to the fact that the larger plants normally have a higher industrial engineering department, making it possible to develop tools such as standard data, to permit more efficient setting of standard allowances.

INDIRECT LABOR OPERATIONS

On Fig. 8, the three indirect labor operations of pouring, melting and shakeout plot fairly even. Here again, the larger plants have the most coverage and perhaps for the same reasons as for the direct labor groups. The indirect labor group, consisting of those employees who are strictly termed supporting labor, shows a much lower percentage of coverage, with the exception of group four, the 200 to 300 employee group. There seems to be no apparent reason for this group having the highest percentage of coverage of supporting labor.

The author believes it is the goal of most premium payment plans to make it possible for the direct worker to attain an average performance of 125 to 130 per cent, and the indirect worker an average performance of 115-120 per cent. On Fig. 9, the second group of 126 to 150 per cent for direct labor appears to be well balanced in all groups except number four, which indicates that the largest percentage of those

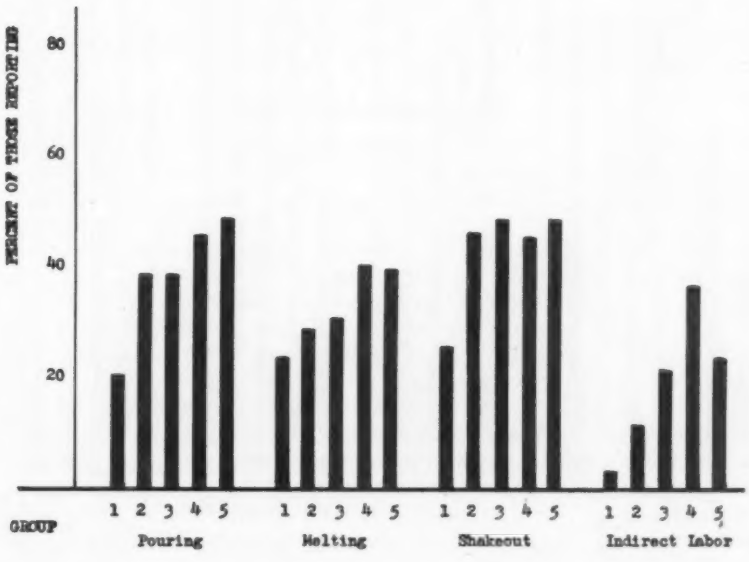


Fig. 8 — Standard/piece work coverage.

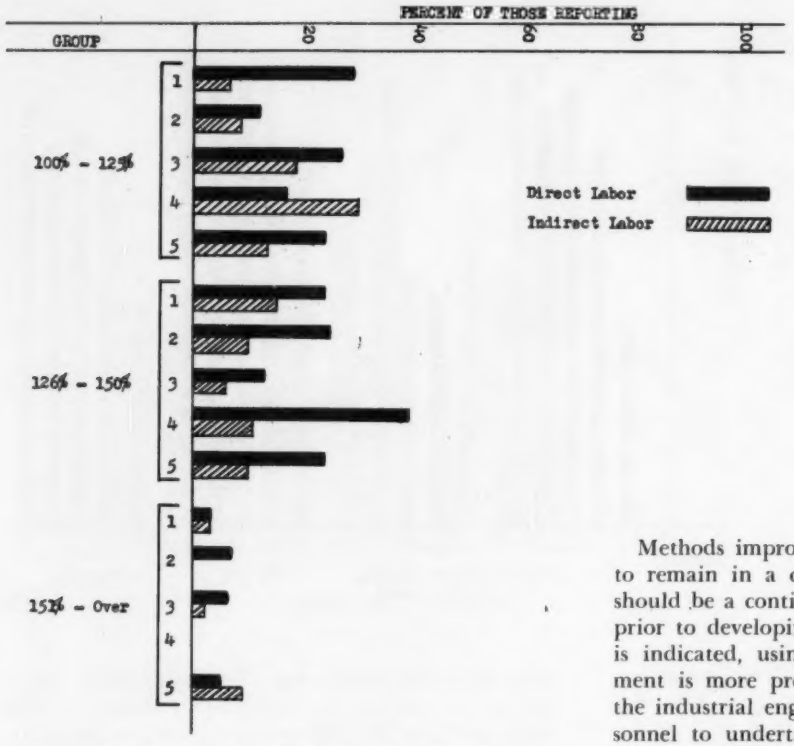


Fig. 9 — Performance experience.

reporting have an average of 140 per cent performance for their direct labor and approximately 110 per cent performance for their indirect labor.

Few companies indicate averages of over 150 per cent and they are, for the most part, traced to those plants having an old established system with standards reviewed only occasionally and a poor method of maintaining their standards or rates. The chart would indicate that a large percentage of the foundry industry have their premium plans well under control.

Many companies, when analyzing the cost of installing and administering a standard hour plan, think only of the advantages obtained through standard or above standard performance. There are several other advantages to be realized as indicated by Fig. 10.

Estimating and pricing are the two most widely used applications to which standard times may be put to use. These two applications make it possible for intelligent quoting when bidding for jobs, and accurate pricing of all castings. This eliminates the "guesstimating" otherwise necessary, and places both the estimating and pricing on a sound basis. Foundries with the proper tools for estimating and pricing are in a position to know whether they can bid on the work and make a nominal profit, and are in a much better position competitively.

CONTROL METHODS

Production control is an important function which can be properly administered only if such tools as standard allowed times are available. This not only permits the daily scheduling of work, but also makes it possible to project the work load of the plant for a given period of time, thus informing management well in advance of their future requirements.

Methods improvement is a must if the industry is to remain in a competitive position. This function should be a continuous drive, and should be applied prior to developing standards for the operations. As is indicated, using standards for methods improvement is more prevalent in the larger plants where the industrial engineering department has more personnel to undertake the problem. In many of the larger foundries this function is performed by a subdepartment entirely separate from the regular time-study group whose objective is to determine allowed times.

The use of standards for labor analysis reports indicates the lowest percentage of the five applications charted. This is an important function. It not only provides the departmental supervisor with a barometer by which he can measure the efficiency and/or operating costs of his department, but also provides top management with a condensed and complete report of the plant's operations. The labor analysis report provides management with an advance notice that the plant is being operated properly, or wave the red flag when costs are going the other way. The use of standards for this purpose is, without a doubt, increasing as the coverage for standard allowed times is increased.

INDUSTRIAL ENGINEERING DUTIES

Figures 11 and 12 may help determine what duties should be performed by the industrial engineering department. This question is asked by both management and the industrial engineering department. Many of the responses indicated all the functions listed as being performed by the department. This is especially true of those companies not employing a large number of personnel for engineering work.

Taking time studies, developing standard data, work simplification, job estimating and plant layout are the most common functions performed by this department. Time keeping, payrolling and material specifications show the lowest percentage, but can and are well placed under the engineering department's control, especially material specifications. The type of materials used naturally has its effects on the

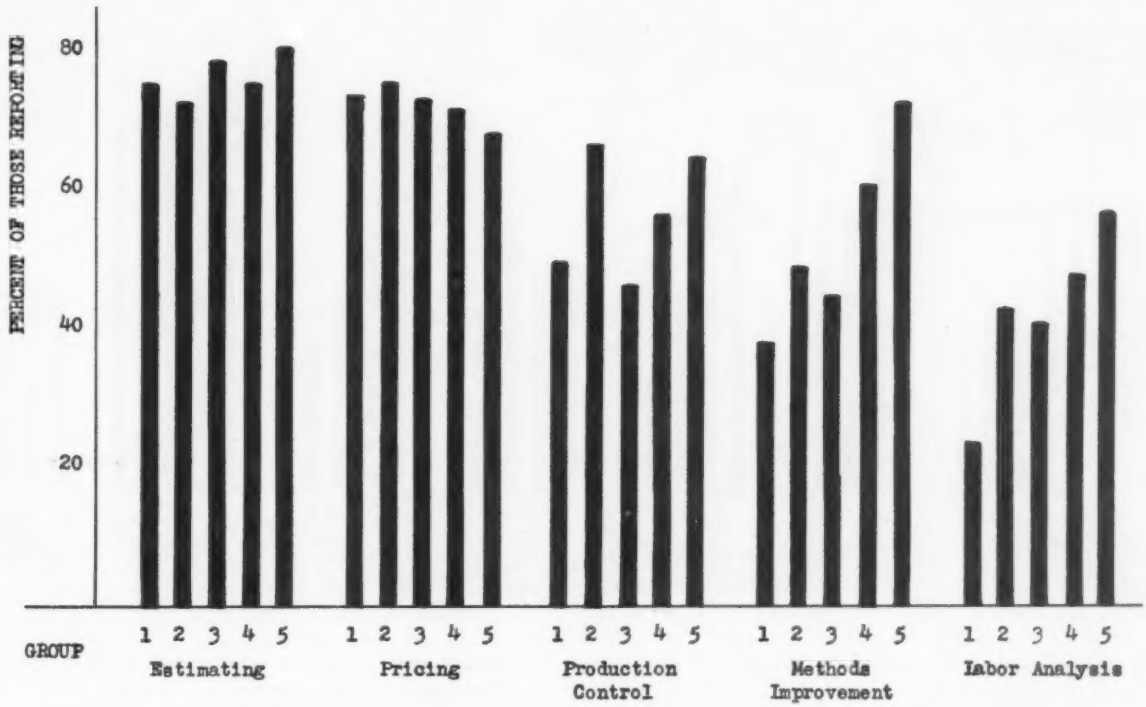


Fig. 10 — Standard times use for other wage payments.

allowed times, and if this function is performed by the department, it is constantly aware of any changes made and in a position to make the necessary comparisons.

The pricing of castings is, when the tools are available, calculated according to the standard allowances for the various elements of work necessary to produce the part. Therefore, the engineering department is perhaps the best informed as to what must be incorporated into the price structure and the function can well be one of their prime duties.

The quality of work performed definitely affects the allowed times, and the administration of this function must either be controlled by the industrial

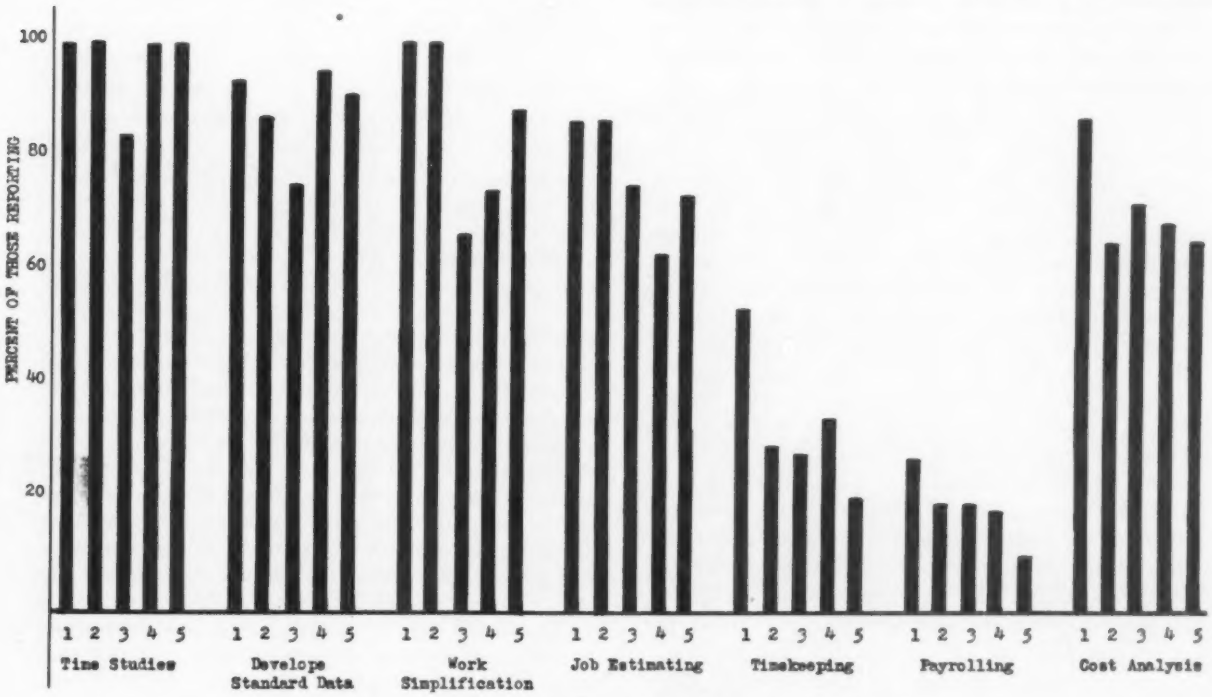


Fig. 11 — Duties performed by industrial engineering department.

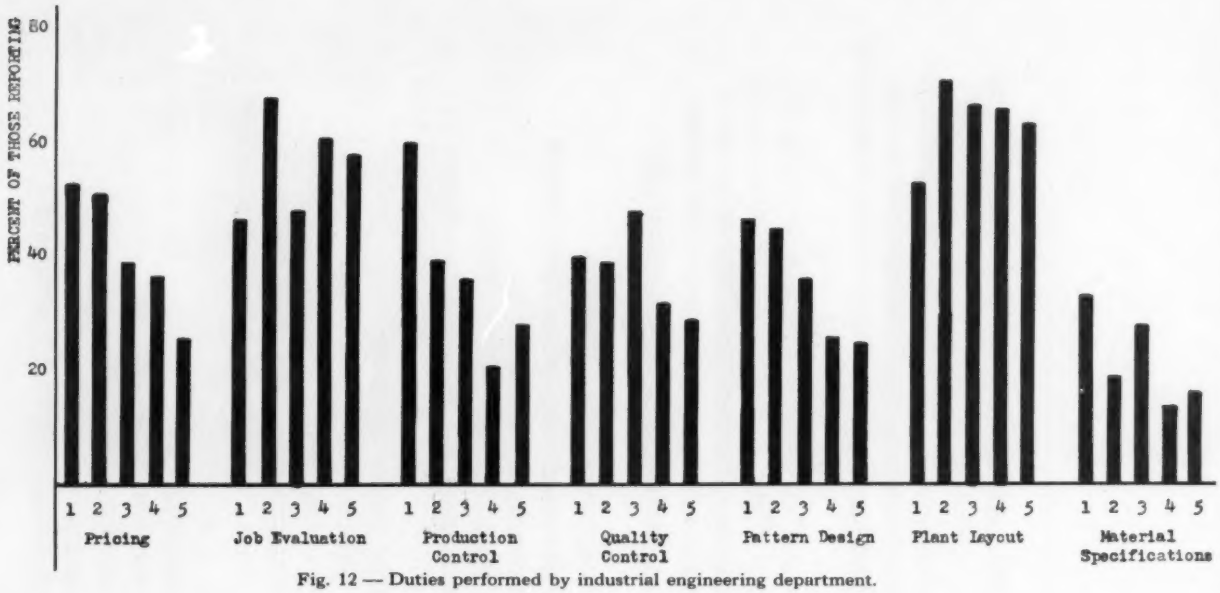


Fig. 12 — Duties performed by industrial engineering department.

engineering department or performed in conjunction with the department.

Payrolling is another function which ties in with industrial engineering, and is in many instances being included in their duties.

Job evaluation is based upon the duties and responsibilities, as well as other factors concerned with specific jobs within the plant. The developing of allowed times, methods improvement and other functions, cannot require elements of work to be performed and/or under conditions which are in conflict with the job descriptions used to determine the job classifications. The advantage of having both functions under the control of the same department is advantageous from the standpoint of efficiency and eliminates overlapping of departments.

Pattern Equipment Design

Pattern design is an important function of the foundry industry. The proper design of the pattern equipment to be used is not only necessary for production of a casting of the proper shape, contour and design, but is definitely a part of work simplification, quality control, estimating, standards, pricing and production control. Since a large portion of the industrial engineers job is to determine the methods and allowed times to produce a quality casting at the lowest possible price, it is only logical that they should have a definite part in the design of the pattern equipment to be used.

Some of the functions charted are, in many companies, performed by personnel of other departments, or, in smaller foundries, by members of top management. However, upon observing the charts, it verifies the fact that all these functions can and are being performed by those having a broad experience in industrial engineering.

An important advantage of incorporating these functions all within the industrial engineering department has proved to be invaluable as a training ground for top management personnel, since they will have attained a broad experience in many of the problems of management, and will have also acquired a vast experience in human relations while performing their tasks.

There are many more comparisons which might have been made from the responses received, but the ones charted were thought to be the ones most helpful to the industry as a whole.

Many incentive, piece work or profit sharing plans have been installed within the last five years, while the greatest percentage of those responding have had such a plan for five to 15 years. There was also a large number reporting plans in effect from 20 to 50 years.

STANDARDS REVIEW

The portion of the questionnaire asking for data relative to the "reviewing of standards" was perhaps the least impressive of all the questions listed. Most of the plants having some sort of premium plan answered only as "periodically reviewed." Nine per cent stated that they made semi-annual reviews, six per cent replied making them annually, while the balance replied only "reviewed as needed."

There have been many papers published on the "Maintenance of Standards," and the author believes everyone is aware of the necessity of keeping a close check on standards if a workable system is to be maintained.

Since chart 9 indicates an average performance of 126 to 150 per cent, leading to the belief that the industry as a whole has a desirable overall performance, there may have been some confusion as to what was meant by "reviewing of standards." It is hoped that this is the reason for the low percentage of reviews, otherwise the survey would indicate that a good job of keeping "up-to-date" is not being done.

DIE CASTING DIE STEELS HEAT TREATMENT AND RELATED PROBLEMS

A fundamental review

by D. R. Edgerton and N. O. Kates

ABSTRACT

The busy die caster cannot find time to wade through the vast amount of data, all of it most excellent, which is furnished by the suppliers of die steels along with the technical papers related to the steels used in die casting, their manufacture and treatment.

While it is most difficult to adequately search out all of the causes of die failures, the authors have made an attempt to catalogue the contributing factors based on nearly 20 years of heat treating experience. Die failures are costly, and it is believed that a study of the possible causes for such failures along with a basic review of die steel and heat treating metallurgy may be useful.

CHOICE OF STEELS

There are certain desirable properties which the die caster may expect with proper choice of steel and treatment for die cavities. An ideal material would 1) resist thermal checking, 2) resist thermal shock, 3) resist erosion or solvent action of molten metals, 4) hold size during heat treatment to realistic tolerances in spite of unbalanced sections required by casting design, 5) be readily machinable, preferably in the fully hardened state—or capable of achieving working hardness by low temperature heat treatment and be 6) capable of welding and repairing in the event of design change or failure.

Unfortunately this ideal material is not available, but the research of suppliers and users of die casting dies is aimed at achieving a fool proof material for all types of die casting die blocks.

A wide variety of steels has been used in the manufacture of die casting dies. However, experience has shown that certain basic analyses combine the advantages of machinability and availability with the heat and wear resistance required for normal die casting operations. The composition and treatment of die casting dies is governed by the operating temperatures and the expected operating life of the die. In choosing a steel and treatment, consideration must be given to the shape and size of the casting and the consequent erosion and heat transfer.

There are so many variables that this paper will leave the details of design to the experience of the tool designer and die caster, covering only the available materials and their possible range of usable properties obtainable through heat treatment.

QUALITY OF DIE STEELS AND PURCHASE SPECIFICATIONS

Since the great majority of die casters do not have laboratory facilities for checking the exact chemical analysis, grain size, cleanliness and freedom from imperfections of their purchased steels, they are dependent upon the counsel of steel manufacturers. Since all reputable manufacturers of die castings steels have concentrated on improved quality, it is only common sense to call in the steel supplier as well as the heat treater, either captive or commercial, for decision as to the most economical combination of steel grade, preparation, inspection and heat treatment of the component parts of the proposed die.

Suggested points for decision are:

1) Type and Analysis of steel to be employed for various die components.
2) Method of forging and percentage of reduction to assure uniform structure.
3) Method of pretreatment to ensure most economical machining and minimize size change in final hardening.
4) Method of final hardening to ensure predicated minimum size change and to best utilize the inherent qualities of the steel in operation.

Examination for cleanliness, uniformity and freedom from imperfections are functions which may be entrusted to the steel supplier.

Supersonic testing is one of the most important in process services of the supplier, and is a definite "must" for larger die blocks, cores and slides. Selection of material and methods of preparation should be based upon safety and quality rather than on possible savings of material and time. The cost of steel

D. R. EDGERTON is Sales Met., and N. O. KATES is Chief Met., Lindberg Steel Treating Co., Chicago.

is indeed a small item in proportion to the ultimate cost of a complete die.

EXPLANATION OF TABLE

In an effort to simplify the choice of steels and cut down inventory, the authors have listed certain tried and proved steels chosen for their availability and desirable properties, as shown in the table.

The steels have been arbitrarily classified according to their service application. Class I, which might contain any variety of steel from straight carbon to the highest alloys, lists P-20 (basically an A.I.S.I. 4130) for die temperature applications up to about 600 F (310 C). This is a chromium molybdenum steel of 0.30-0.35 per cent carbon, chosen in preference to various similar grades because of availability, machinability and other desirable properties.

Likewise, the P-3 grade of hobbing steel has been found to have properties of availability and workability which recommend it over other hobbing steels for multiple cavity work on low melting alloy die castings. The core hardness of 200-300 Brinell may be sufficient for surface wear resistance without carburizing.

Class II for aluminum lists four of the most common chromium type alloys. Each has its combination of desirable properties, with the H-11 and H-13 steels somewhat increasing in use over the H-12 and H-14 types containing tungsten.

P-4 hobbing grades has gained popularity for hobbed cavities. P-4 is the low carbon member of the chromium hot-work family and has the same favorable properties. The normal core hardness obtainable of 270-330 Brinell is sufficient to withstand the heat, wear and pressure of zinc and aluminum die casting, while the surface hardness may be increased by nitriding or by carburizing to a medium carbon potential of 0.35-0.45 per cent. This practice is used successfully for larger production in aluminum.

Class III lists the higher alloys generally used for brass die casting, of which three are in general use. H-20 and H-21 are used interchangeably and the cobalt-tungsten type is used where greater red hardness is required.

For uses other than cavities, four miscellaneous steels should cover most of the die caster's requirements. The H-26 and H-42 low carbon high speed steels may be used for cores, core pins or ejector pins along with nitride alloy "G", (used only in the nitrided condition) while the "G" parts will operate safely at most die casting temperatures, the H-26 and H-42 pins will maintain core hardnesses of 50-55 Rockwell C (up to 1300 F, 700 C) with resulting higher compressive strength.

DIE CASTING DIE STEELS

CLASS	A.I.S.I. NO.	Composition, % C	Mn	Si	Cr	Mo	V	W	Other	USES
1	P-20	0.30	—	—	0.75	0.25	—	—	—	Zinc & low melting point alloys
	P-3	0.10	—	—	0.60	—	—	—	1.25 Ni	Hobbing cavities for low m.p. alloys
2	H-11	0.35	—	—	5.00	1.50	0.40	—	—	Aluminum, Magnesium and their alloys
	H-12	0.35	—	—	5.00	1.50	0.40	1.50	—	
	H-13	0.35	—	—	5.00	1.50	1.00	—	—	
	H-14	0.40	—	—	5.00	—	—	5.00	—	
	P-4	0.07	—	—	5.00	—	—	—	—	Hobbing cavities for Al-Mg alloys
3	H-20	0.35	—	—	2.00	—	—	9.00	—	Brass and Copper alloys
	H-21	0.35	—	—	3.50	—	—	9.00	—	
	Cobalt Tungsten	0.30	—	—	1.40	0.40	—	4.00	5.00 Co	
Misc. Steels	H-26	0.50	—	—	4.00	—	1.00	18.00	—	Ejector pins and cores
	H-42	0.60	—	—	4.00	5.00	2.00	6.00	—	
	Nitride Alloy "G"	0.35	—	—	1.25	0.20	—	—	1.25 Al	
	A.I.S.I.-S.A.E. 4140*	0.40	0.90	—	0.90	0.25	—	—	—	Holding blocks

*Low alloy casting may be substituted for 4140 forged blocks.

HEAT TREATMENT CHARACTERISTICS OF EACH CLASS OF STEELS

Class I — Zinc and Low Melting Point Alloys

Steels of this group are usually oil quenched and tempered to the desired hardness. They are relatively shallow hardening, but analysis may be varied to increase depth of hardness.

For the normal operating temperatures of zinc, 350 F to 600 F, in the die and up to 775 F (425 C) casting temperatures. The die sections are normally drawn to 280-340 Brinell, a compromise between machinability and service life.

If high production is required, any of the 5 steels listed in Class II may be substituted and treated to hardness of 380-420 Brinell after machining.

Compromises indicated by design intricacy are sometimes effected by the use of a Class I steel, machined in the soft annealed state to within approximately $\frac{3}{16}$-in. of finished size and then hardened to 380-420 Brinell, followed by finish machining to size with carbide tools. Another method of compromise is to nitride inserts placed in critical areas to increase its life.

Where dies are operated at the lower hardness ranges, 250-350 Brinell, the low hardness may create the problem of sinking and wearing at the shut-off area between top and bottom dies. In such cases, flame hardening is recommended. Figure 1 illustrates the method employed. Progressive heating with oxy-cetylene flame, to approximately 1550 F (840 C) followed by a suitable quenching medium, (usually a noninflammable, soluble oil) develops surface hardness of 450-500 Brinell. A tempering at approximately 450 F (220 C) will relieve quenching stresses without softening the surface appreciably, and will provide a suitable surface hardness about $\frac{3}{16}$-in. in depth.

Class II — The Chromium Hot Work Steels

Steels of this class, used principally for aluminum die casting, are somewhat more difficult to machine

than the low alloys. Free machining agents have been employed to overcome this difficulty, but most dies are still machined in the annealed state. Although they must be hardened at higher temperatures of 1825-1900 F (995-1035 C), their analysis permits air hardening and deep penetration of hardness, in turn alloying closer control of size. After tempering (multiple drawing is recommended) at 1025-1125 F (545-600 C) dies may be operated at approximately 600 F preheated temperature, and with casting surface temperatures up to 1150 F-1200 F (630-650 C).

The best operating hardness of Class II dies is a problem requiring a compromise between possible cleavage and heat checking failure. There are those who believe that the greater the hardness the greater the resistance to washing and heat checking.

However, to obtain best properties for this combination of safety and die life—44 to 48 Rockwell C is usually specified.

Where design increases the possibility of failure due to cleavage cracks, a hardness of 41 to 44 Rockwell C may be specified as a means of increasing the safety factor at some sacrifice to ultimate die life.

In cases where operating factors permit, the hardness of the cavity may be increased to 48-50 Rockwell C to take advantage of increased erosion resistance.

If Class II Steels are used for long run zinc die casting, they may be left as hard as 48-52 Rockwell C.

Class III — For Brass and High Melting Point Alloys

The high alloy steels may be of various analyses. Most commonly used are the 9 per cent tungsten type and the cobalt-tungsten type. Considerable variations in analysis have been developed by steel suppliers. Since the alloy content may vary from 10 to almost 25 per cent in these high alloys, they are more difficult to manufacture, machine, weld and heat treat than are the milder alloys. They are used largely for brass die casting or for pins and inserts for severe aluminum and magnesium alloy service. The hardness specifications normally follow those of Class II.

Miscellaneous Steels

It is generally conceded that the fewer different steels used in die construction the better. A wide variety of steels increases the chance for error and requires a costly inventory.

The table lists only four steels. A.I.S.I. H-26 and A.I.S.I. H-42 are interchangeable. Either will make an excellent core pin, and either will nitride nicely. The 135 nitride alloy may be used interchangeably with P-20 (4130).

There is a definite trend toward the use of holding blocks of low alloy constructional steels treated to 250-350 Brinell with nitrided slides and pins, and with insert blocks and stationary cores of higher alloy materials.

Alloying elements in the table are added for definite reasons and in quantity shown by experience to meet the greatest percentage of requirements; such as hardness, toughness, wear resistance and heat resistance. Carbon and manganese are the principal hardening agents.

Fig. 1 — Flame hardening shutoff area.

Chromium increases hardenability, adds some strength at high temperatures, and increases wear resistance. Cobalt contributes to red hardness. Molybdenum refines grain, deepens hardening, counteracts tendency toward temper brittleness and raises hot strength and red hardness. Nickel strengthens and toughens. Tungsten increases wear resistance and promotes hardness and strength at higher temperatures. Vanadium refines grain, increases hardenability, resists tempering, and causes marked secondary hardening.[8]

METALLURGY OF HEAT TREATING

The three classes of steel used for die impressions have different hardening characteristics due to their varying alloy content. The basic principles of heat treatment apply to all of the steels used in the manufacture of die casting dies and their components. There are several ways of classifying heat treatment, though in general they fall into two classes.

1) There is the type of heat treatment whereby the surface composition of the steel is altered in such a way as to induce a high degree of hardness, such as in nitriding, or to produce a composition and structure capable of being hardened to a high degree, such as in carburizing.
2) There is the type of treatment which involves a heating and cooling cycle only for materials which already possess the elements necessary to harden the part of the desired properties.

Briefly, the heat treatment of steels can be simply expressed by stating that in the annealed machinable condition the steel is soft, consisting internally of an aggregate of ferrite and carbide. Upon heating above the critical temperature, the crystal structure of fer-

rite changes becoming austenite, which dissolves a large portion of the carbide. This new structure, austenite, is always a prerequisite for hardening. By quenching, that is cooling rapidly to room temperature, the carbon is retained in the solution and the structure known as martensite results. This is the hard structure which is sought in steel, in order to obtain specialized properties for many applications.

Martensite is initially high stressed, for the transformation from austenite involves some volumetric expansion against the natural resistance of the steel. It must be reheated to an intermediate temperature to slightly soften it and relieve the internal stresses that may embrittle the steel. This is known as tempering.

If quenching is not rapid enough, the austenite reverts to a fine mixture of ferrite and carbide known as pearlite, and high hardness is not obtained. The quenching rate which will produce martensite depends primarily on the alloy content. Plain carbon or low alloy steels may be water or oil quenched while highly alloyed steels usually can be hardened in air or quenched in hot oil or salt at approximately 400 F (205 C).

Time-Temperature-Transformation Curves

The steel producer research laboratories have developed the thermal cardiograms of heat treatable steels which have been invaluable in developing optimum heat treating procedures. The charts tell us that the products of decomposition are entirely dependent upon the rate and manner of cooling. Thus the time-temperature-transformation (TTT) diagram shows the time required for decomposition to start and end at any given temperature. A wide variety of structures may be formed during this decomposition depending on the temperature and length of time during which this decomposition is effected.

For obtaining maximum hardness, it is, of course, necessary to form a completely martensitic structure. Martensite is formed by the decomposition of undercooled austenite so that for the conditions, dependent upon the analysis of the steel, cooling must take place at a controlled rate so no decomposition takes place until the temperature reaches the martensite start point.

As cooling proceeds from this martensite start temperature, known as M_s temperature, and below, the austenite decomposes into martensite with variable amounts of retained austenite, depending on the amount of alloy in the material being heat treated.

The TTT diagram gives the structures and hardness that will be obtained if transformation is completed at a constant temperature. In continuous cooling, the structure will depend on the time that the steel remains in the various transformation levels (i.e., the cooling rate).

Hardenability

The most significant practical attribute of a steel is its capacity to be hardened or hardenability. This term refers to the depth of hardening, or to the size of a piece that can be fully hardened under a given set of cooling conditions. In a given steel, maximum hardness is dependent almost entirely on the carbon content, whereas the depth of hardness depends on the carbon, alloy content and austenitic grain size.

Since the hardness of steel increases as the transformation temperature is lowered to the M_s, it is essential to prevent transformation at the higher temperature. This requires cooling the steel with sufficient rapidity to pass the nose of the TTT curve before transformation starts. In general, the suitability of a steel for a given heat treatment is determined by its hardenability, which in turn is influenced by carbon content. Alloy steels can be quenched to martensite more slowly than carbon steels. Alloy elements differ greatly in their effects on transformation rates, but the effects of these elements are cumulative. Basically then, die steels must be heat treated in the following manner:

1) The dies must be properly supported to prevent sagging and heated to a slow enough rate to ensure uniformity between heavy and light sections. The die surfaces should be adequately protected at the elevated temperature by the use of protective controlled atmosphere, or by pack hardening in inert materials such as pitch coke or cast iron chips which may remain neutral to the material at the hardening temperature.
2) The dies must be held at the specified maximum temperature for sufficient time to insure complete solution of the carbide and alloying elements in the iron, in order to obtain a homogeneous solid solution, austenite.
3) The die steels must then be cooled at the proper rate to ensure complete hardening to martensite. If it is cooled too slowly, a slack-hardened structure will be obtained. If cooling is too rapid, that is faster than is necessary, cracking may occur due to thermal and transformational stresses.

Figure 2a shows the TTT curve for the low alloy, P-20 type, A.I.S.I. 4130 type steel. In a plain or straight type carbon steel there is less than 5 sec to quench past the left-hand side of the curve in order to avoid soft products or a slack-hardened structure. With P-20 there is nearly ½ min to get past the nose of the *S* curve. In dies of small cross-section, less than 2 in. may be quenched into hot oil or salt in order to avoid excessive distortion.

Figure 2b illustrates the TTT curve for the H-13 type of alloy die casting steel. One can immediately notice that the additional alloy slows the cooling rate sufficiently, (approximately 8 min to avoid the 1300 F portion of the *S* curve) to alloy air cooling to harden even large die clocks. The deep hardening characteristics of this grade and the basically deep hardening characteristics of all the higher alloy types allows the heat treater to air cool, and thus maintain closer control over dimensional movement and deformation curing the quenching operation.

The Class III type of die casting steels have a TTT curve which indicates that one can cool past 1400 F in 40 to 45 min and still have adequate cooling to harden. These high-speed type die steels require high austenitizing temperatures in the neighborhood

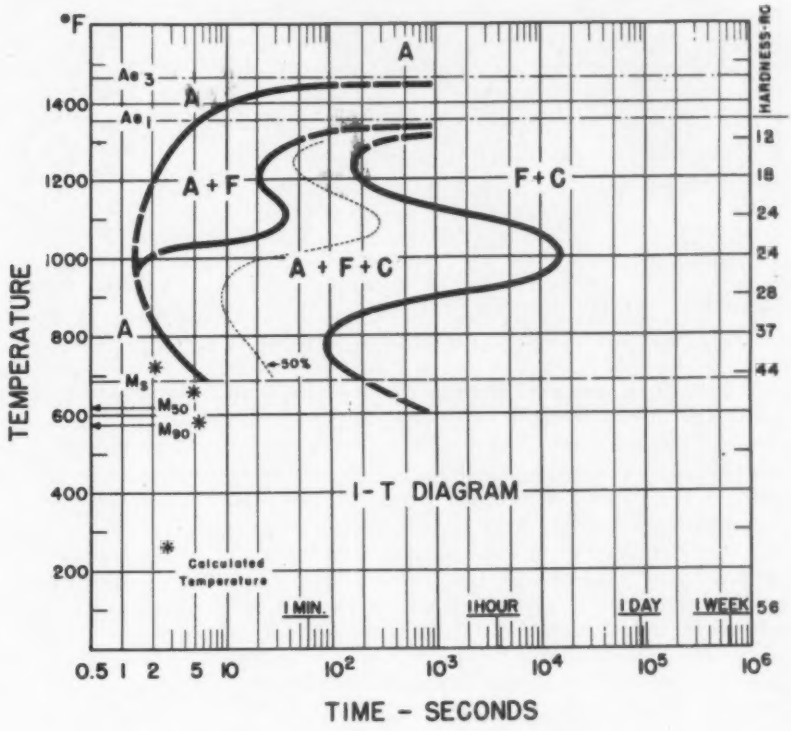


Fig. 2a — Time-Temperature-Transformation curve for P-20 die steel. Austenitizing temperature 1500-1600 F. *A* — austenite; *F* — ferrite; *C* — cementite; *M* — martensite.

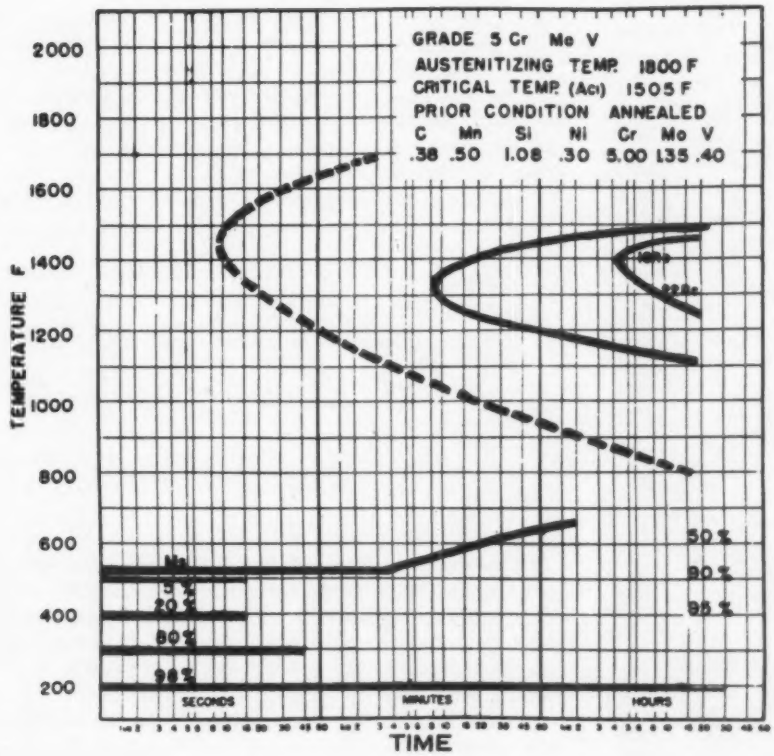


Fig. 2b — Time-Temperature-Transformation curve for H-13 die steel.

of 2100-2200 F (1150-1205 C). These steels must be heat treated in carefully controlled neutral salt baths or controlled atmosphere in order to avoid serious surface contamination which may be created at the elevated hardening temperature.

The austenitizing aspects of the major grades can be summarized:

1) P-20 type—austenitize 1600 F oil or salt quench.
2) H-13 type—austenitize 1800-1900 F and air cool.
3) H-21 type—austenitize 2100-2200 F hot quench in 1100 F salt or air cool.

Tempering

Tempering of the fully hardened steel is required for the relief of quenching stresses, and to recover the necessary toughness and ductility required to withstand service stresses. Since alloy steels contain elements that increase temperability, the Class II and III show much greater resistance to softening than do the P-20 or straight carbon steels. Basically, the higher the alloy content the higher the tempering temperature required and the necessity for multiple tempering.

The ability to maintain hardness at the elevated tempering temperature is, of course, the reason for using the high alloy content of chromium and tungsten for the aluminum and brass die casting dies. Multiple tempering is a must for Class II and Class III die casting steels. By virtue of the fact that these steels do not completely transform the retained austenite with single tempering, a second and even a third temper is required in order to assure that the conditioned austenite has been transformed to martensite and fully tempered. Multiple tempering will provide reasonable assurance that the intricate dies, with frail projections and variable cross-section will not drift at the operating temperature.

While there is a spread of recommended times for tempering all three classes of die steel, the following schedule has worked out as a reasonable compromise of furnace time and cost as against reliability and safety in service.

Class I
Double Draw one hr/in. of cross-section.
Operating Temperature of Die—300-500 F (150-250 C).
Draw Temperature—650 F (340 C) to 1050 F.
Useful hardness varies from 30-45 Rockwell C according to section.

Class II
Double Draw one hr/in. of cross-section.
Operating Temperature of Die—600-1000 F (315-540 C).
Draw Temperature—1025-1150 F (500-620 C).
Useful hardness—40-50 Rockwell C.

Class III
Double Draw one hr/in. of cross-section.
Operating Temperature of Die—1000-1400 F (540-760 C).
Useful hardness—40-52 Rockwell C.

In tempering at the above temperatures there are certain rules to observe:

1) Suitable air circulating draw furnaces must be employed to insure uniform temperature throughout the mass.
2) To ensure sufficient draw time on large cavity blocks, it is recommended that thermocouples be placed near the center of the block so that rate of heat penetrations can be measured.
3) Accuracy of temperature must be maintained since slight temperature variation will cause hardness variation of beyond desired specifications.

It is obvious that each type of die steel must be handled slightly differently from the others for optimum results. Different temperatures, different heating and cooling rates and variable tempering procedures must be used.

The properties of die steels developed in heat treatment bear an important indirect effect on their die life. In general, it may be said that the harder a given die the longer it will wear, while the softer a die the tougher it becomes. Thus, presuming the proper die steel is being used and no other factors are operative, dies which are wearing out should be harder for improved life, and dies which are breaking or cracking should be made softer.

STRUCTURES FOR MACHINING

Referring back to the TTT Curves, it will be noted that if the steel in question is cooled slowly enough from the critical quenching temperature, the resulting structure will be a soft lamellar pearlite along with varying amounts of alloy ferrite, plus some carbide particles at the grain boundaries. As the speed of cooling is increased, the lamellas become finer and harder until the critical cooling rate for hardening is reached. For each of the three types of steel, there are hardnesses at which the best combination of properties for surface finish and machinability are secured.

Following are suggested treatments for meeting hardness specifications for specific machining procedures:

Class I, A.I.S.I.
180-210 Brinell—Annealed.
210-300 Brinell—Normalized and/or Quenched and Tempered.
300-450 Brinell—Oil Quenched and Tempered.

Class II
190-220 Brinell—Annealed.
220-500 Brinell—Quenched and Tempered.

Class III
220-230 Brinell—Annealed.

The optimum heat treatment for various machining depends on the application, design intricacy and the economics of die construction. In general, where heat treat size change is intolerable, die components are machined in the pretreated or tempered martensite condition.

Rough machining, plus conventional heat treating to ascertain dimensional movement for use in predicting final heat treat size change is frequently employed on extensive die programs.

There is no fixed rule for machinability of any of

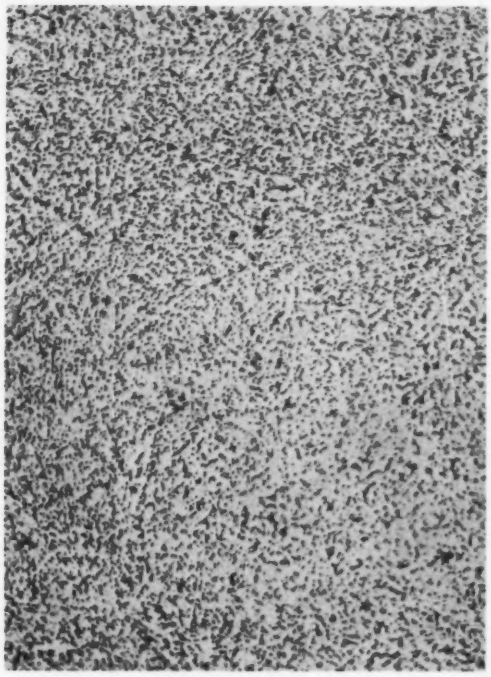


Fig. 3a — Annealed structure H-13 steel. 200 ×.

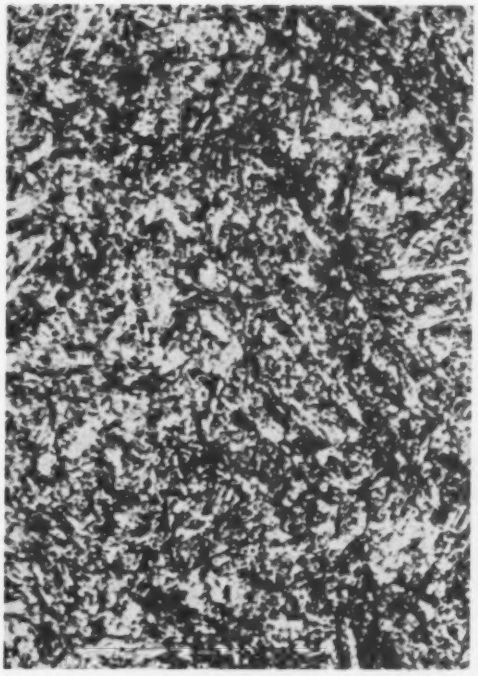


Fig. 3b — Prehardened structure H-13 steel. 1000 ×.

the three classes of steel. Blocks may be purchased either in the soft annealed (Fig. 3a) or the prehardened condition (Fig. 3b). It is recommended that each job be investigated as to cost versus service life required, and the most economical combination be decided upon while the die is still in the blueprint stage.

With improved steels, machine tools, cutters and lubricants, certain dies may be finished at the higher operating hardnesses thus eliminating the factor of size change in heat treatment. However, at the higher hardnesses hand barbering and polishing for fitting is the normal final operation.

Preheat Rough Cavity for Size Change Prevue

The cavity was roughed out to within $\frac{1}{16}$-in. of final size and measured. It was then air quenched from 1825 F (995 C), double tempered at 1050 F (575 C) to 48 Rockwell C and measured. After annealing to 230 Brinell, the cavity was machined to size, allowing for approximately half the original growth in final hardening. The cavity was held within a maximum allowable change of 0.010 in. (Fig. 4). It was estimated that with an error of only 0.015-0.020 in. in figuring expansion, an extra $\frac{1}{4}$-lb of aluminum would be used for each casting. On 100,000 castings this would amount to 25,000 pounds of aluminum. This shows the importance of size change.

NITRIDING—FOR CLOSE TOLERANCES, INCREASED WEAR, AND ANTI-SOLDERING

Nitriding has become more widely used as a method for:

1) Maintaining the wear resistance of slides and other moving parts.
2) Increasing the wear and yet maintaining the built in accuracy of pretreated and machined dies, inserts, pins and sleeves.
3) Process designed to prevent soldering or sticking of castings on dies in which design cannot eliminate trouble areas.

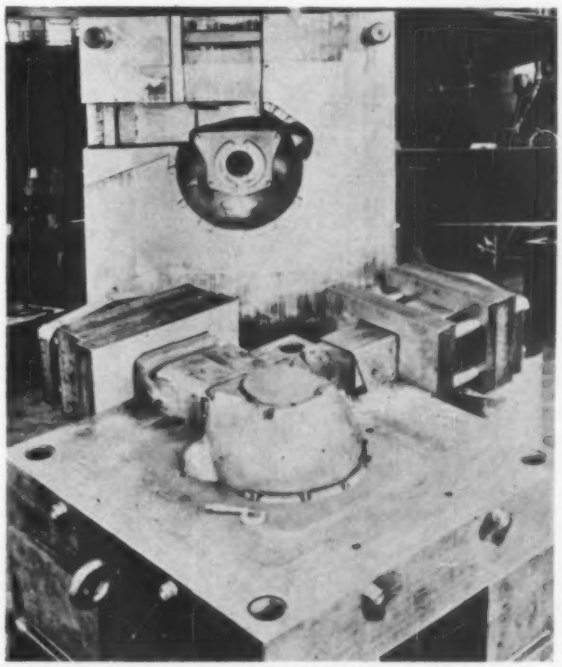


Fig. 4 — Cavity block of H-13 steel inserted in hold block of 4140 S.A.E. Weight of gravity block, 6500 lb; weight of casting, 22 lb.

The nitriding process lends itself well to parts for the most intricate and unusual designs. Due to the fact that the nitriding operation is carried on at a relatively low temperature, and that no quenching operation is necessary, it naturally follows that distortion will be a minimum and that the danger of hardening cracks is eliminated. Thus, it is possible to surface harden parts which have been machined at a machinable hardness to the desired intricacy. Thorough hardening parts of intricate design may almost be out of the question and still obtain the close tolerances required.

The most important factor to be considered in the design of parts to be nitrided is the elimination of sharp corners. It is not always necessary that edges and corners be actually rounded, but they must at least be broken by means such as an oil stone. The nitrided case is hard and brittle so that a sharp edge and corner have a concentrated buildup of nitride and may cause chipping at that point.

NITRIDING PROCESS

The nitriding process is effective for most of the steels listed in the table due to the fact that their composition, which contains vanadium, tungsten, chromium and molybdenum, will form with atomic nitrogen created by the decomposition of ammonia to form hard nitrides at the surface. Nitriding is carried on in a closed retort with ammonia gas, decomposing at the nitriding temperature of 950-980 F to produce atomic nitrogen and hydrogen. Nitrogen is absorbed by the steel at the temperature (which is below the original tempering temperature) in much the same manner as carbon is absorbed and diffused during the high temperature process of carburizing. However, at the nitriding temperature (below any critical temperature) size change is minimized and the normal tempered hardnesses maintained.

Nitriding has been and is being used more frequently prompted by the needs for increased pressures and production. It has also been said that the compressive stresses created by the nitrided case (approximately 0.008-0.012) does promote favorable compressive stresses at the surface, which are opposed to the operating stresses during the die casting operations. Thus far, the use of nitriding has been confined to wearing parts and inserts which tend to wash out due to location turbulence which usually causes stickers. A second reason is because after the parts have been nitrided it is extremely difficult to change or repair the part. Unless the case is largely removed, such as by grinding, machining or welding, to repair or change design is difficult.

It is therefore suggested that nitriding be considered carefully, and then only used on inserts or die parts that may be easily replaced. Figure 5 illustrates a microstructure of a case in a nitrided alloy, as well as the depth, Knoop hardness and survey of the hardened nitrided zone.

Liquid nitriding using equal percentages of potassium and sodium cyanide can be accomplished at operating temperatures of 1025-1050 F on small inserts. The process is fast and economical, and can produce a case depth of about 0.001 in 5 hr. The disadvantages of the liquid nitriding process is the shallow case which permits little or no grinding, and, most important, the tendency of salt to pick up moisture and cause rusting and pitting. Liquid nitrided parts must be immediately washed free of salt and lightly vapor blasted and oiled to prevent pitting.

SURFACE CONTROL IN HEAT TREATMENT

An important factor in the heat treatment of die casting dies to secure maximum die life is that of surface chemistry control. The oxygen in the air and the water vapor and carbon dioxide in burned fuel gases will rapidly deplete the carbon on the surface of the steel at the elevated temperature used in heat treating unless the surface is adequately protected. A loss of carbon at the surface means a loss of surface hardness and a loss in desirable surface properties. No longer is the surface of the die the same alloy which was carefully chosen, purchased and manufactured into a die.

Decarburization can result in early surface fatigue with resultant pitting, washing and general curtailed die life. Figure 6 reveals decarburized microstructure and Fig. 7 shows normal structure.

Historically, surface protection has been provided by pack hardening in a completely burned compound known as pitch-coke and is reasonably neutral to the conventional die steel. Pack hardening does a good job, but is expensive and time consuming because of the large box and packing material which must be utilized for proper heating of the die. Considerable time is required to heat this large mass of insulating material, plus the expense consumed in the manufacture of the large steel containers.

Various methods of surface protection during pack hardening have been employed due to the lack of integrity of the neutrality of the packing. Copper plating and various protective paints are used which were designed to brush off easily after heat treatment. Both plating and painting presented cleaning problems which could manifest itself in surface pits and imperfections that could cause problems in service.

Since it was generally conceded that surface decarburization or carburization (Figs. 6, 7) of die casting surfaces could promote washing or earlier heat checking, heat treatments utilizing controlled atmosphere or molten salt baths are most widely used.

Muffle or Retort Furnaces

Modern die surface protection is provided by the use of special muffle or retort furnaces, wherein the dies are protected from contact with the combustion gases and surrounded by special atmospheres neutral to the surface chemistry of the die steels.

There are many controlled atmospheres available, such as argon, nitrogen, completely dissociated ammonia and dry hydrogen which may be used in retort furnaces. However, endothermic atmosphere is the most common. The reason for this is that the endothermic atmosphere is an economical atmosphere, and the one that can be easily tuned to the particular carbon content of the die steel being

Case Depth Inches	Hardness Rockwell C
0.002	60.5
0.004	59
0.006	59
0.008	58.5
0.010	58
0.012	56
0.014	51
0.016	47
0.018	39
0.020	27
0.022	26
0.024	26

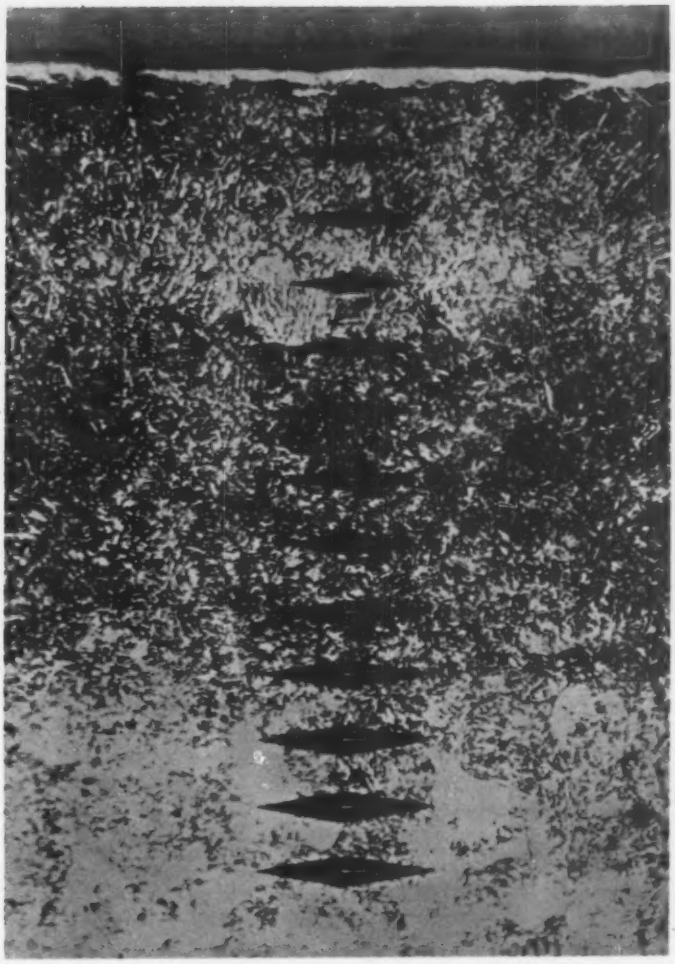


Fig. 5 — Microstructure and case hardness of a case in a nitrided alloy.

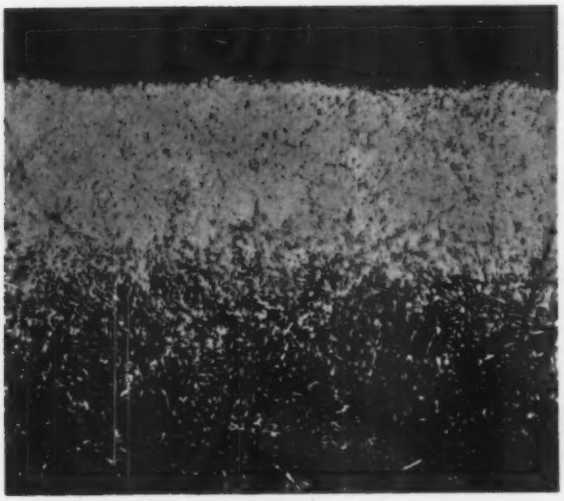


Fig. 6 — Decarburized surface. 200 ×.

Fig. 7 — Normal surface. 200 ×.

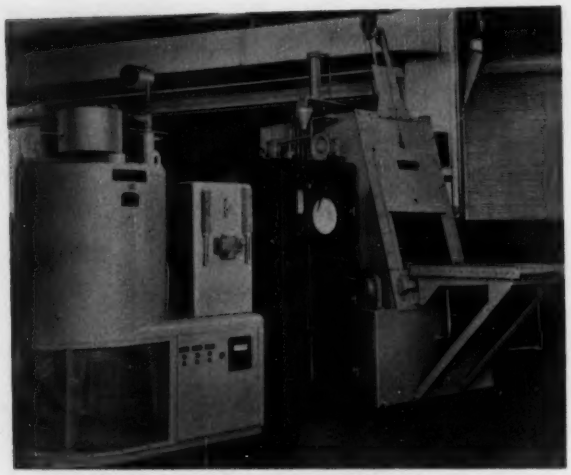


Fig. 8 — A typical endothermic generator with carbon control and controlled atmosphere furnace.

treated. The other atmospheres are relatively inert to to the carbon of the die steel being treated, are expensive, and may not overcome decarburizing conditions created by furnace or retort leaks.

The endothermic atmosphere, which is produced by reacting air and gas (such as propane, butane or natural) over a heated catalyst provides an atmosphere consisting of basically 40 per cent hydrogen, 40 per cent nitrogen and 20 per cent carbon monoxide. It has been found that the relatively simple method of measuring the dew point (water vapor) is a reflection of the water/gas reaction between carbon monoxide and water vapor. The dew point is the quickest and most accurate indication of the carbon dioxide and moisture, and thus the carbon potential of the atmosphere. By simple regulation of the air/gas ratio the dew point can be regulated to be in complete neutrality to the steel being heat treated.

Figure 8 shows a typical endothermic generator, furnace and associated dew-point controller and recorder. Figure 9 shows dew-point equilibrium chart for carbon steels.

SALT BATHS

Molten salt baths (Fig. 10) are now generally recognized as an excellent medium for the heat treatment of high speed steels and are widely used for hot-work steels. Salt baths large enough to handle die casting dies of substantial size find greater use in Europe than in the United States. The development of ceramic lined furnaces with totally submerged electrodes, together with new and improved methods of salt rectification, has greatly simplified the operation of salt baths. The use of 100 per cent anhydrous barium chloride with a melting point of 1750 F (955 C) and a working range of 1900-2400 F (1035-1315 C) for the higher temperature die casting die steels has proved staisfactory. However, where the dies are extremely intricate and designed with manifold cooling lines honeycombed throughout the die block, salt cleaning after hardening may present a problem. Pitting and corrosion are constant hazards.

FAILURE OF DIE CASTING DIES

Cracking

Cracking or splitting may occur in heat treating or in service from several causes. Deep tool marks, sharp corners, absence of fillets and unbalanced sections are all stress raisers and should be avoided.

One of the difficulties encountered by metallurgists who seek to determine the cause of die failures is the frailty of the "genus homo." No operator will ever admit a bad setup, a double shot or turning cold water onto a hot die. Then too, there is generally more than one possible contributing factor to ultimate die failure.

Figure 11 shows a typical failure. The die was

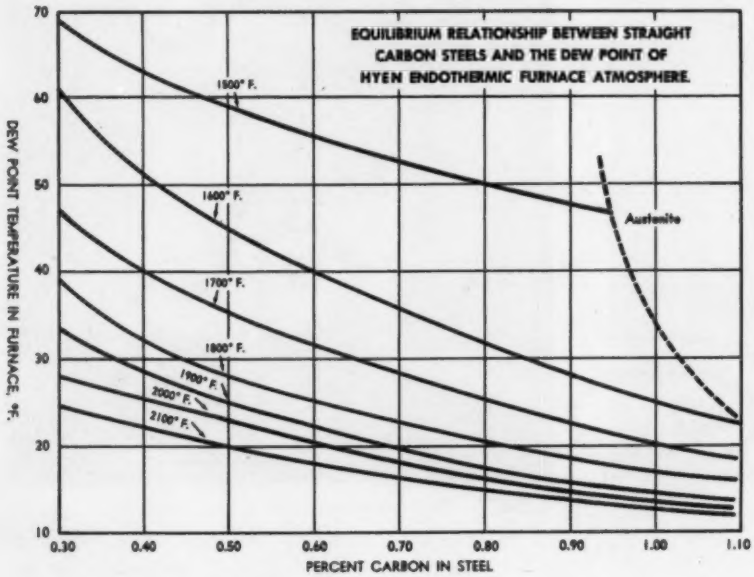


Fig. 9 — Dew point equilibrium chart for carbon steels. Alloy additions cause slight variations.

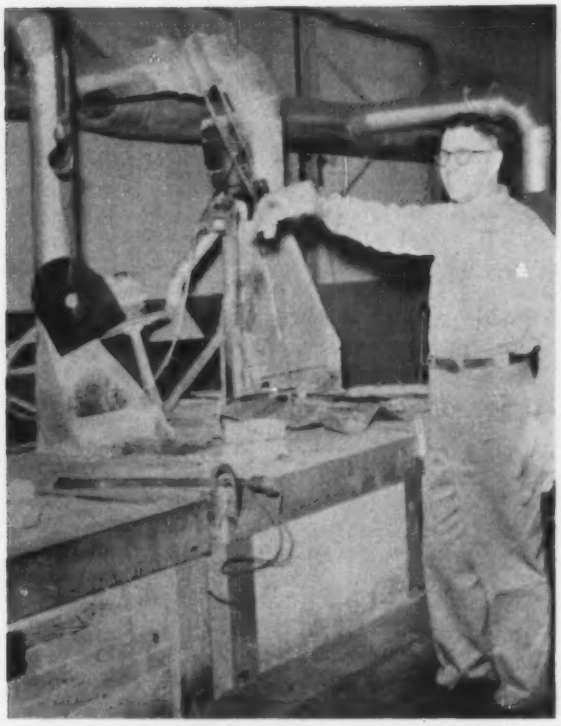


Fig. 10 — Salt bath preheat, high heat and quench.

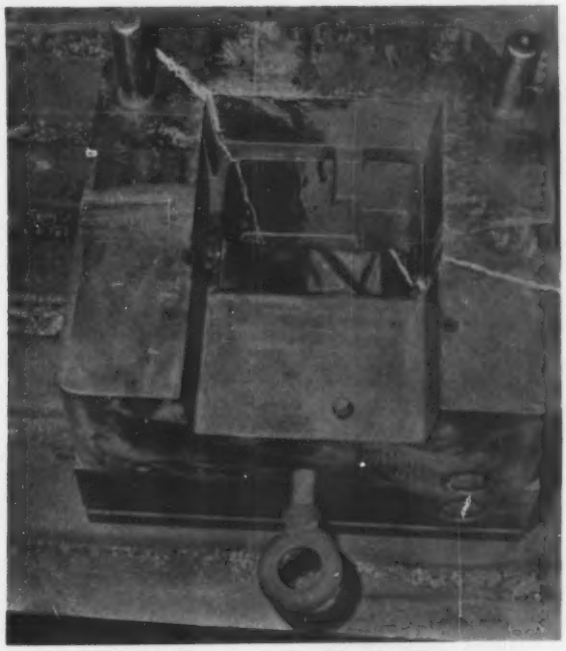


Fig. 11 — Failed cavity H-13 steel. This is believed to be caused in this case by unbalanced section and sharp corners.

H-13 and was eight weeks behind schedule. The forging source and the heat treater were rushed. The tool maker requested radii in the sharp corners and a thickening of the cavity bottom (to even out the section), but was refused. The die was rushed into service, a crack started in the sharp corner, perhaps aided by improper preheat or alignment, and progressed in less than 8 hr operation completely through the die.

A similar failure in Fig. 12 was blamed upon an improperly reamed water line. The crack had started at the torn point where two drills missed meeting by ⅛-in., creating a focal point for fatigue cracking. Figure 13 shows aluminum surface impregnation from running a soft die prior to heat treatment.

Heat Checking

Heat checking may be caused by improper gating or by overheating of the surface layer of metal along with improper preheating of the die. Castings allowed to cool in the die (stickers) seem to promote localized overheating and checking.

Heat treating can contribute carburization or decarburization of die surfaces. Either condition may subject the metal to differential stresses because of the difference in ductility between the parent metal and the carburized or decarburized surface. Mild carburization is preferable to decarburized surfaces. Figures 14 and 15 show this condition with progressive checking and buildup of aluminum in the cracks.

It is believed that tool marks, minute inclusions or other unusual surface imperfections may act as foci for surface stresses and hasten the formation of checks. Perhaps minute pit marks open up into checks as shown in Figs. 16 and 17.*

Washing

Washing is usually caused by direct impingement of hot metal on a flat surface, giving the hot metal

*Roberts and Grobe, Vanadium Alloys Steel Co. in "Service Failures of Aluminum Die Casting Dies."

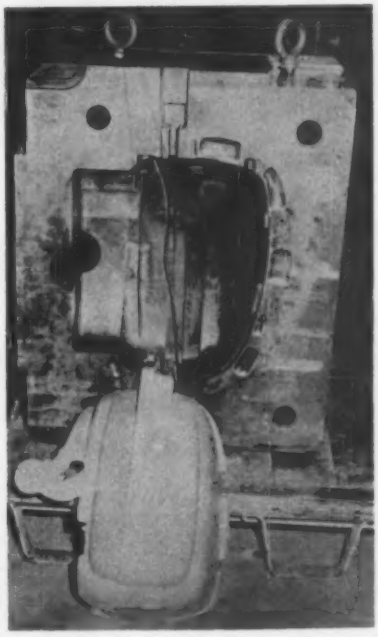


Fig. 12 — Failure starting from unreamed water line.

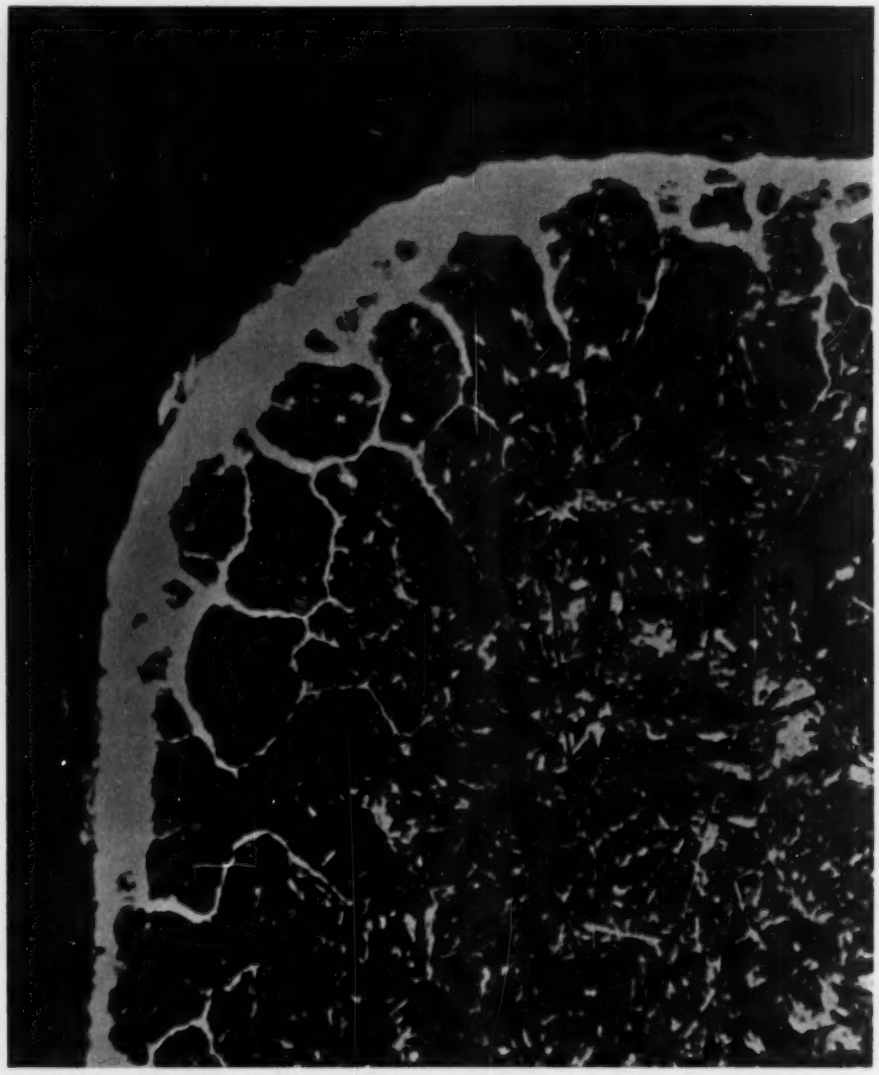


Fig. 13 — Aluminum surface impregnation from running a soft die prior to heat treatment.

a chance to exert unusual surface pressure or tension.

Over tempering or under hardening, or any other cause for surface softening can promote washing. It is not always possible to divide or break up the metal flowing from the gate and thus reduce the pressure. Nitriding has been found to give greater resistance to washing than is exerted by the die surfaces at normal hardnesses. All three classes of die materials may be nitrided, and actual practice has proved that surfaces thus protected will usually stop the washing action. Nitrided inserts containing the gates and made of higher alloy material have proved beneficial. It is not usually wise or necessary to nitride the entire cavity. If surface is decarburized nitriding will cause spalling.

Soldering

Soldering, or the pickup of molten metal on the die casting die surface, is thought to be caused by minute imperfections. Figure 18 and Fig. 19 show the development of such an imperfection.

Care in "breaking in" a die with use of proper lubricants is essential to die life. Any method of eliminating pit marks or imperfections is of assistance. Light sandblasting, vapor blasting and surface plating with silver or iron oxide and phosphide coatings are all practices that help to cut down on the chances for soldering. Figure 20 illustrates die insert showing impingement soldering.

SUMMARY

Experience would seem to indicate that certain basic rules apply to the successful preparation and operation of die casting dies as follows:

1) Buy only from reputable steel suppliers and secure their advice as to: A) type of steel, B) forging direction and C) forging reduction.
2) Use a minimum number of steels and avoid special purpose steels unless required.

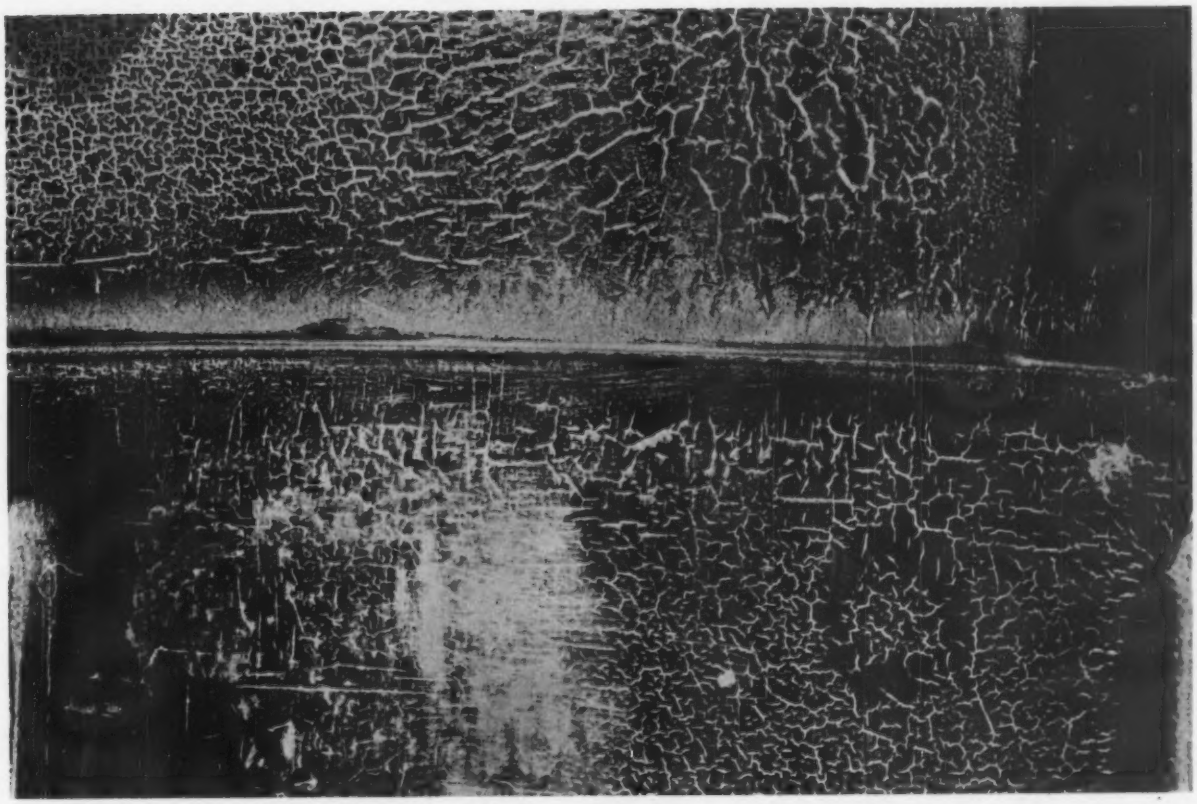


Fig. 14 — Typical heat checks on die surface (H-13 steel).

Fig. 15 — Buildup of aluminum in surface checks. 14 ×.

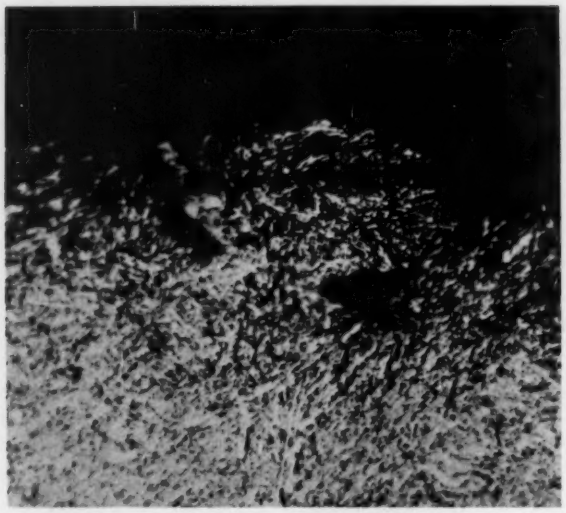


Fig. 16 — Initial surface pit, H-13 material. 500 ×.

3) Observe normal safety rules for die design such as balanced sections, generous fillets and wide radii. Keep water lines as far from casting surfaces as possible and ream all water line holes.
4) Be sure than your heat treater has adequate equipment to develop best properties to assure satisfactory maximum performance and die life. Furnish information as to size change allowances, material and hardness specifications, and surface finishes required. Above all do not rush him.
5) Cooperate with the heat treater in building up a store of knowledge gained from experience in treating the three classes of steel described. Use pretreatment of rough block in order to predicate potential size change in finished die, or pretreatment and nitriding with dimensional accuracy is required.
6) Observe all possible precautions during the "break in" period. The die must be carefully preheated, properly aligned and above all must be protected

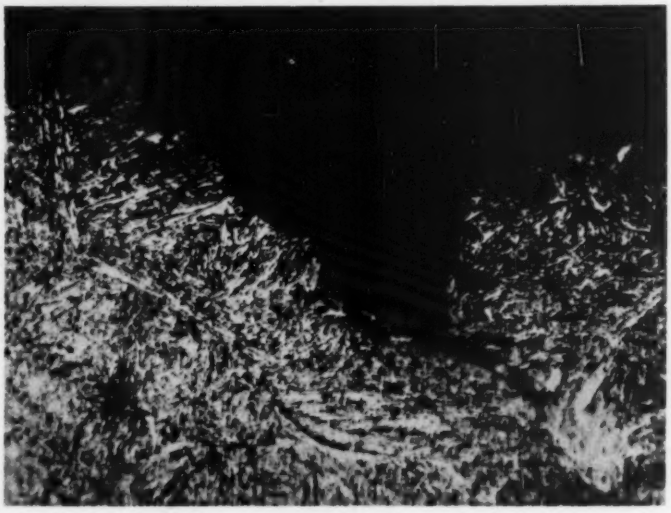


Fig. 17 — Pit developed into surface check. 500 ×.

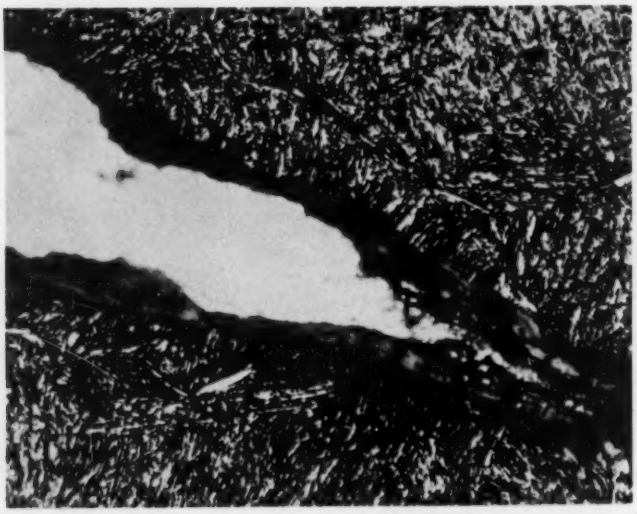


Fig. 18 — Aluminum trapped in heat check by oxide films.

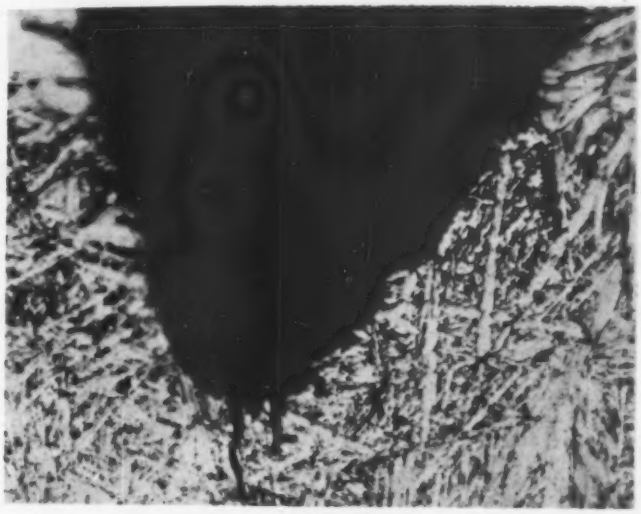


Fig. 19 — Surface check which traps the die cast cast metal and promotes soldering or sticking. H-13 material.

Fig. 20 — Die insert showing impingement soldering.

by proper lubricants and be free from pits, scratches and surface defects. If dies must be "run-in" soft, check for surface checks with a magnetic particle inspection and remove incipient cracks before final heat treatment.

ACKNOWLEDGMENTS

The authors wish to thank the following steel companies for their excellent cooperation: Allegheny Ludlum Steel Corp., Braeburn Alloy Steel Corp., Carpenter Steel Co., Columbia Tool Steel Co., Crucible Steel Co. of America, Firth Sterling Inc., Jessop Steel Co., Latrobe Steel Co., Universal-Cyclops Steel Corp., Vanadium Alloys Steel Co. and Vulcan Crucible Steel Co.

They also are deeply indebted to Mr. A. M. Patel and the other members of the Lindberg Steel Treating Co., Met. Dept., and to Mr. William Klein of the Lindberg Engineering Co., for their invaluable assistance.

Figures 3-a, 3-b, 7 and 8 are courtesy Braeburn Alloy Steel Corp., Braeburn, Pa., Fig. 4 is courtesy Atols Tool & Mold Co., Chicago, Figs. 9 and 10 are courtesy Lindberg Engineering Co., Chicago, Fig. 11 is courtesy Charles Zapf & Co., Evanston, Ill., Fig. 12 is courtesy Johnson Motor Co., Div. Outboard Marine & Manufacturing Co., Waukegan, Ill., Figs. 14, 15, 16, 17, 18 and 19 are courtesy Vanadium Alloys Steel Co., Latrobe, Pa.

REFERENCES

1. P. Payson and J. L. Klein, "The Hardening of Tool Steels," *A.S.M. Transactions, vol. 31*, p. 218 (1943).
2. H. H. Doehler, "Die Casting."
3. Post, Fetzer and Fenstermacher, "Air Hardenability of Steels," *A.S.M. Transactions, vol. 35*, p. 85 (1945).
4. James L. Erickson, "Checking of Die Casting Dies," *Steel Magazine, vol. 156*, p. 64 (Sept. 20, 1945).
5. H. Chase, "Selecting Steels for Casting Dies," *Steel Magazine, vol. 120*, no. 2, p. 98 (Jan. 13, 1947).
6. G. A. Roberts, A. H. Grove and C. F. Moersch, Jr., "The Tempering of High Alloy Tool Steels," *A.S.M. Transactions, vol. 39*, p. 521 and 548 (1947).
7. R. F. Harvey, "How to Identify a Good Hot Work Die," *Steel Magazine* (Oct. 19, 1959).
8. *American Society for Metals Handbook*, 1948 Edition.

PHYSICAL AND CHEMICAL CONDITIONS VARIATION EFFECT ON BENTONITE SUSPENSION PROPERTIES

by A. J. Anderson and G. J. Sutton

ABSTRACT

This article embraces the results of an investigation into the effect on Bingham yield value of bentonite suspensions produced by the addition of reagents, some of which resemble those which could occur under natural conditions. The effect of these reagents on the pH of bentonite suspensions has also been examined.

By means of differential thermal analysis it was shown that phosphate ions are adsorbed into interlayer and lattice positions. It was also shown that tannates and similar reagents are not adsorbed.

INTRODUCTION

In recent years, some sand foundries have endeavored to avoid the wastage of castings associated with defects caused by "scabbing" "erosion" and "rough surface." One of the means of achieving this has been to improve the molding sands by control of their hydrogen ion concentration. Much of the work was carried out in foundries and has not been reported in the literature. However, various authors have published articles between 1938-1954 on the subject, but, in general, the reported results are not extensive.

The defects mentioned are related to the bond strength developed in the molding sand. This characteristic, usually described as "green compression strength," is developed in the sand as a result of the bond produced by the clay matter present. Naturally, any investigations into the effect of the variation of pH of the molding sands must be approached from the viewpoint of the effect of variation of pH on the bonding clay. It is considered that the clay in a "green" molding sand is in a semi-plastic condition. Hence, any investigations into the effect of the variation of pH on bonding clay are best carried out on a suspension of such a clay in water.

In Australian foundries, a big proportion of green molding is "synthetic," i.e., a mixture of silica sand, Western Wyoming bentonite and water. Consequently any work on this subject should be based on water suspensions of this clay. It is known that viscosity is the property of such suspensions which is most affected by variation of hydrogen ion concentration.

A. J. ANDERSON and G. J. SUTTON are with The University of New South Wales, Sidney, Australia.

Accordingly, measurements of viscosity (from which Bingham yield values were calculated) were carried out with various types of reagents for reasons given below.

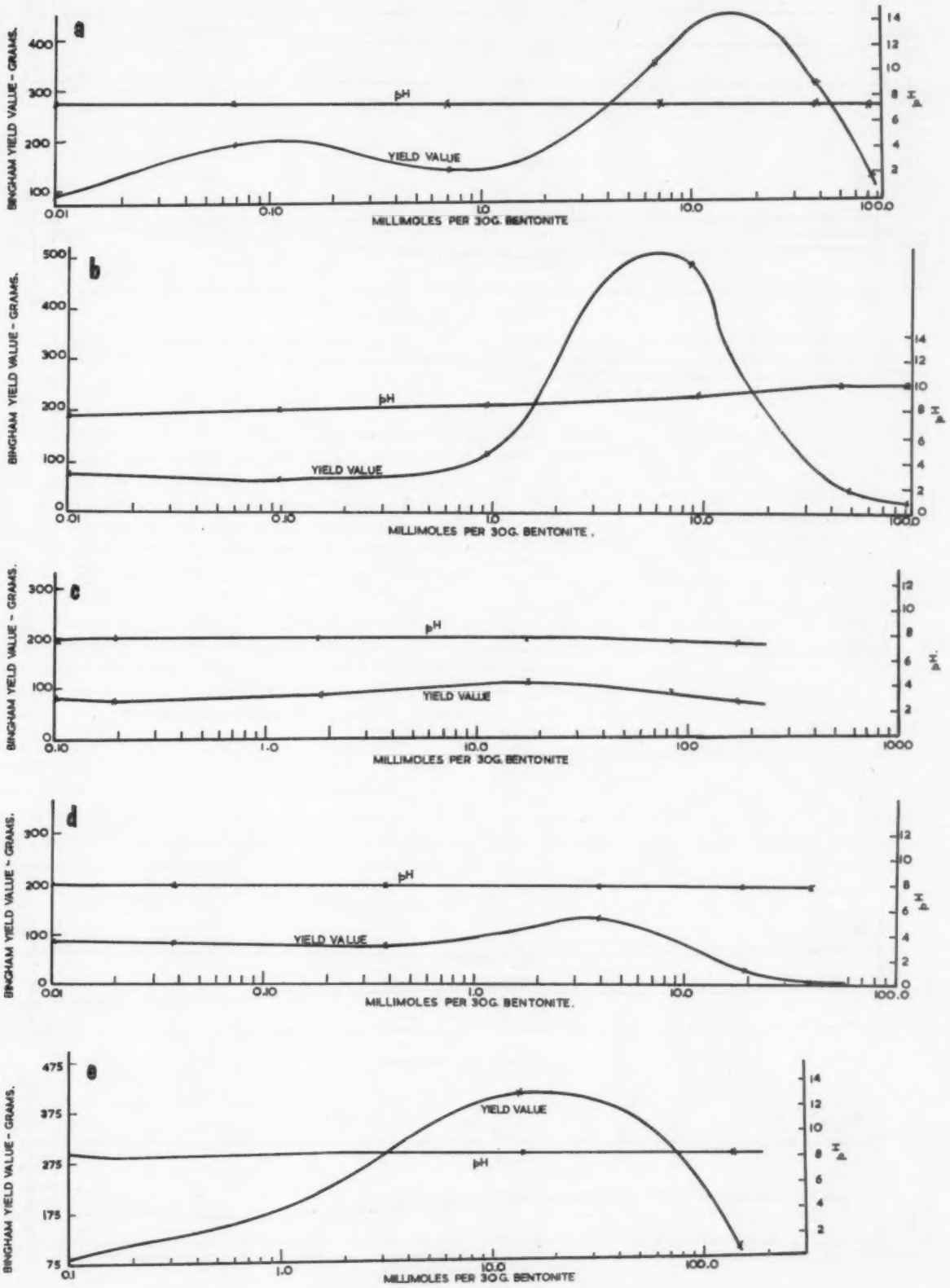
INVESTIGATION PURPOSES

First, it was decided to investigate the addition of anions of both weak and strong acids in order to observe the effect of pH on the suspensions. It was found that salts of weak acids produced peaks in a viscosity curve when viscosity (as expressed by the "Bingham yield value") was plotted (as ordinate) against the concentration of added salt (as abscissa). The results are given in Fig. 1. It is logical that the hydroxyl ions liberated by hydrolysis of the anions of weak acids may be taken up by ions having high polarising power, such as Si^{4+}, Fe^{3+} and Al^{3+} which exist in bentonite suspensions.

The progressive formation of these hydroxides would also assist in maintaining a constant pH with increases in salt concentration. The increase in viscosity to a peak could be due to the above phenomenon, as these substances could be colloidal when freshly formed. The drop in viscosity which followed may be due to precipitation of the colloids, which are positively charged, by excess $(OH)^-$ from the added salt.

When the relative strength of the acid corresponding to the anion of the added salt is compared with the viscosity of the treated suspension, it is observed that in general the extent of the peak is inversely proportional to the strength of the acid. The weaker the acid, corresponding to the anion of the reagent, the greater is the peak. As the acid increases in strength, the yield values (a measure of viscosity) become lower, until salts of a strong base and a strong acid are without appreciable effect on the viscosity of the clay suspensions.

Second, it was decided to investigate the effect of wetting agents on bentonite clay suspensions. Two commercial brands, based on water solutions of sodium dodecyl benzene sulfonate, were used. The results obtained are summarized in Fig. 2. In general, these reagents did not affect the viscosity of the suspensions to any marked extent. The increase in viscosity noticed with one of the reagents is probably



(Fig. 1 — continued on next page)

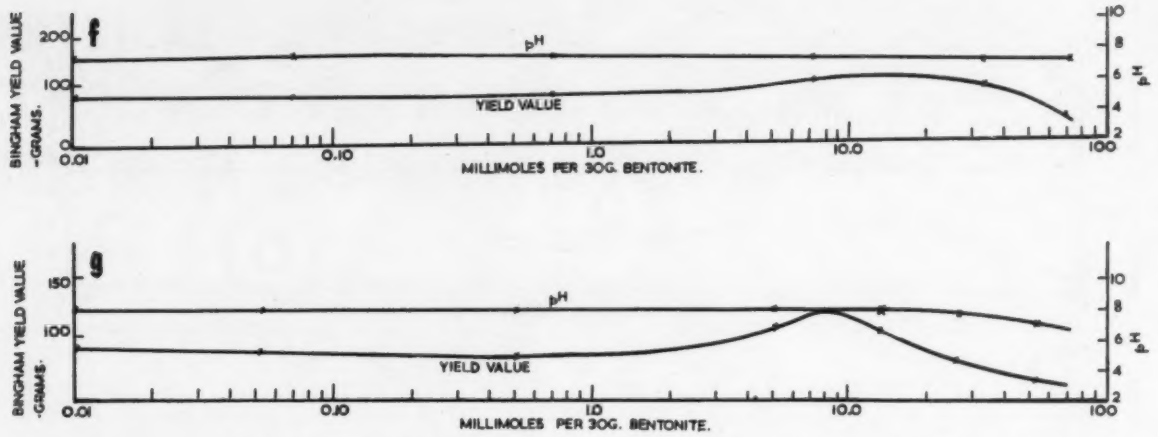


Fig. 1 — The effect of the addition of Group 1 reagents on the yield value and pH of bentonite suspensions. (a) sodium acetate, (b) sodium carbonate, (c) sodium chloride, (d) sodium citrate, (e) sodium formate, (f) sodium sulphate and (g) sodium tartrate.

due to emulsification produced as a result of the stirring action of the rotating viscometer bob. It would appear that the wetting agents do not appreciably affect either the pH or the viscosity of the bentonite suspension.

This is in disagreement with the opinion expressed by Green (1942) that if wetting agents increased wetting, then both the yield value and plastic viscosity would be lowered. Although the dispersion of the bentonite was facilitated in the presence of the wetting agents, no such lowering of the yield value was observed.

Third, it was proposed to study the theory advanced by Lewis, Squires and Broughton (1944) to explain the reduction in viscosity of bentonite suspensions by the presence of tannates which may occur in natural sands. In order to obtain sufficient data, both organic and inorganic reducing agents were used. In addition, salts of organic acids, which were without reducing effect, were added for comparison.

Sodium Gallate Effect

Lewis et al (1936) and others have described the reduction in viscosity produced by the addition of tannins to the bentonite suspensions. The tannin extracts described are a mixture of complex organic compounds. In preference to such a complex mixture as tannin extract, sodium gallate was the first reagent to be used. It will be seen from Fig. 3 that it produced the expected reduction in viscosity. Like gallic acid, succinic acid is likely to be present in decaying vegetable matter, but when the sodium salt was added to the bentonite suspension no comparable reduction in viscosity was observed.

However, succinic acid differs from gallic acid both structurally and in molecular weight. Other cyclic compounds such as sodium salts of benzoic and salicylic acids, which are structurally similar to gallic acid, also failed to exhibit the same characteristic towards bentonite suspensions as was observed

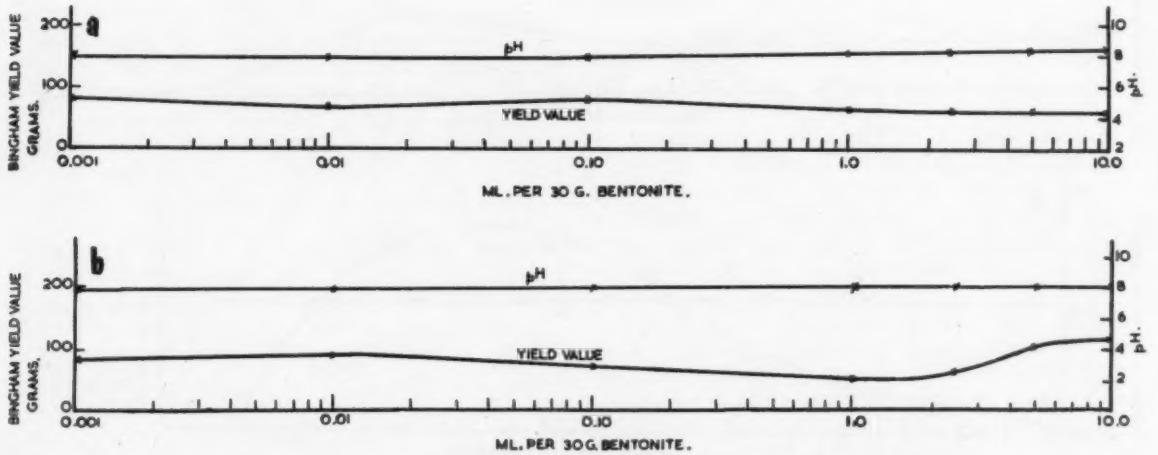
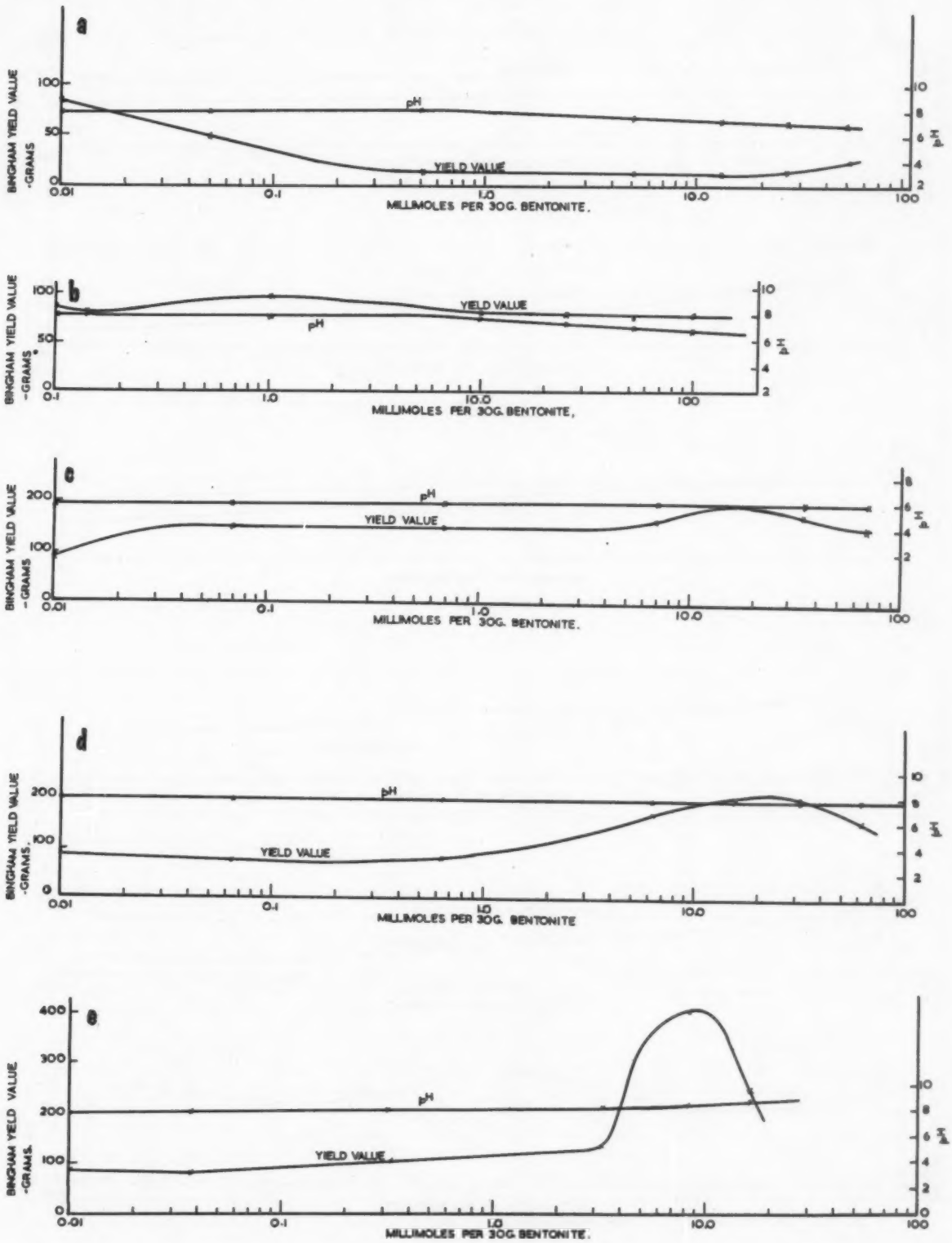
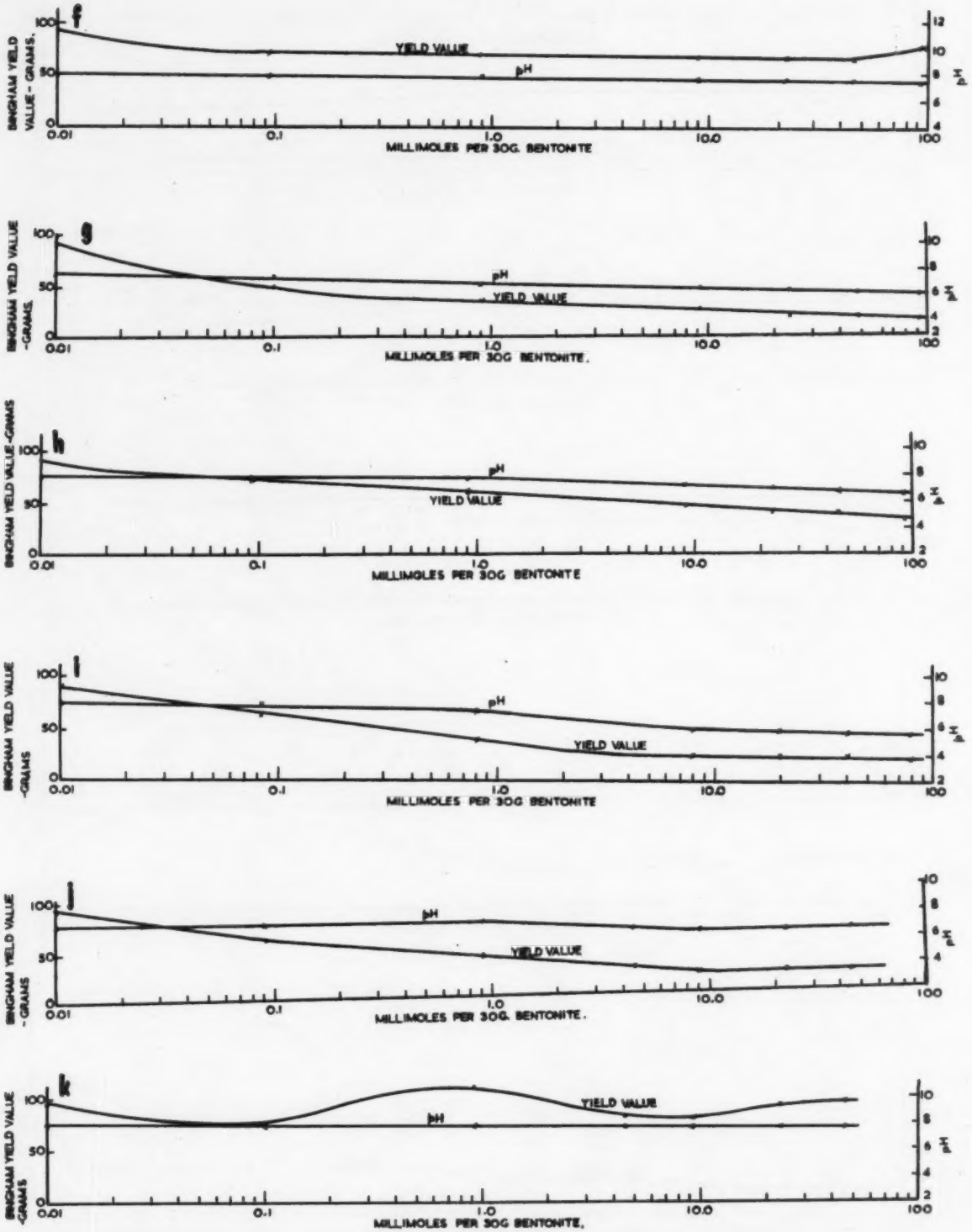


Fig. 2 — The effect of the addition of Group 2 reagents on the yield value and pH of bentonite suspensions. *Top,* wetting agent *A*; *bottom,* wetting agent *B*.



(Fig. 3 — continued on next page)



(Fig. 3 — continued on next page)

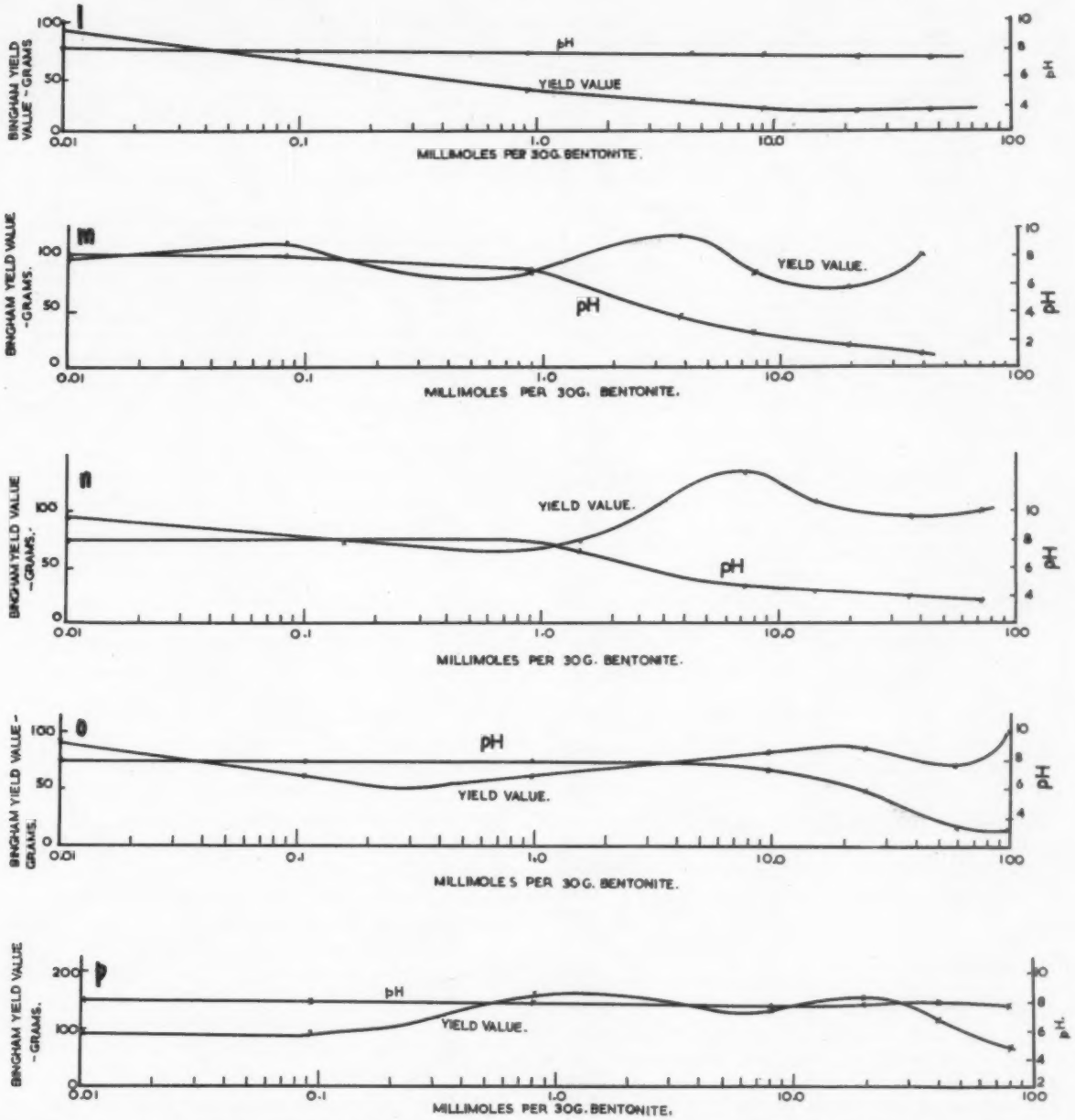


Fig. 3 — The effect of the addition of Group 3 reagents on the yield value and pH of bentonite suspensions. (a) sodium gallate, (b) sodium succinate, (c) sodium benzoate, (d) sodium salicylate, (e) sodium oleate, (f) resorcinol, (g) catechol, (h) hydroquinone, (i) pyrogallic acid, (j) o-amino phenol, (k) m-amino phenol, (l) p-amino phenol, (m) hydrazine sulphate, (n) hydroxylamine hydrochloride, (o) sodium hydrogen sulphite and (p) anhydrous sodium sulphite.

with the salt of gallic acid. Lewis et al (1944) suggested that the effect on bentonite suspensions observed with tannin extracts was due to the high molecular weight of the reagent, yet sodium oleate (molecular weight 304) failed to reduce the viscosity.

It was then suggested that the behavior of the tannins and of the sodium gallate might be due to the ability of these compounds to act as reducing agents. Dihydric phenols offered three reagents, two of which were known to be strong reducing agents and the other a weak reducing agent. The active reducing agents markedly reduced the viscosity of the clay suspensions to which they were added, but the inactive reagent did not affect the viscosity. Pyrogallic acid, o - amino phenol and p - amino phenol also reduced the viscosity of the suspensions.

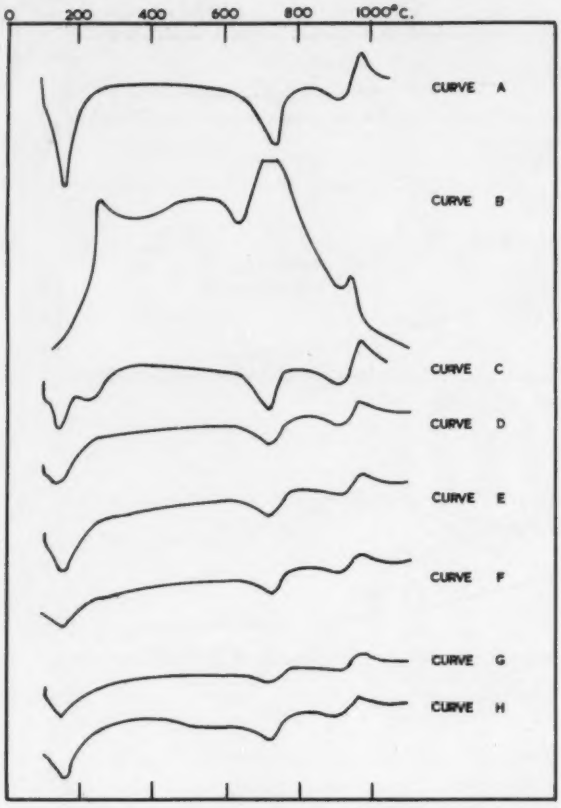


Fig. 4 — Differential thermal analysis curves for bentonite treated with various organic chemicals. All curves — Western Wyoming, Black Hills, bentonite. (A) untreated, (B) treated with methylene blue, (C) treated with p-amino phenol, (D) treated with o-amino phenol, (E) treated with catechol (o-dihydroxy benzene), (F) treated with hydroquinone (p-dihydroxy benzene) and (G) treated with pyrogallol (tri-hydroxy benzene) and (H) treated with sodium gallate.

However m - amino phenol and the inorganic reducing agents, hydrazine sulfate, hydroxylamine hydrochloride, sodium hydrogen sulfite and sodium sulfite failed to produce a similar effect. It now appeared that noticeable reduction in viscosity was brought about by organic compounds possessing a strong reducing action.

Organic Agent Tests

The next step was to establish the nature of the action of these organic reagents on bentonite. Accordingly, samples of clay in the untreated condition, after saturation with methylene blue and after treatment with the reagents found to reduce viscosity, were tested by the following method.

They were thoroughly extracted with alcohol to dissolve excess reagent and subjected to differential thermal analysis. The results are shown in Fig. 4. The methylene blue, which is known to be strongly adsorbed on to the clay lattice produced a distinctive graph.

All of the clays treated with the other reagents produced graphs similar to that of untreated clay, except that the extent of the endothermal changes was reduced due to the alcohol treatment. This result suggests that these organic reducing agents are not adsorbed on to the clay lattice, and hence as far as the clay is concerned their action may be classified as physical rather than chemical. The compounds which markedly reduce the viscosity of the bentonite suspensions belong to a group of reagents called "photographic developers."

They are known to be active reducing agents, and hence it is suggested that their reduction of the viscosity of the bentonite suspensions was due to chemical combination with oxygen which had been adsorbed by the clay particles but was not strongly bonded to the lattice. The removal of the oxygen from the surface facilitated the movement of the clay particles relative to each other during shear and hence reduced the viscosity.

Such an assumption appears compatible with the various theories which have been proposed to explain the formation of thixotropic colloidal suspensions of bentonite in water. It also fits in with the different behavior of the inorganic reducing agents used, whose capacity to combine with oxygen is slower, and hence is probably offset by diffusion of oxygen from the surface in contact with the air during the experimental procedure.

On the other hand the organic reducing agents formed a layer which was practically impermeable to oxygen, thus preventing a return of the oxygen removed. This theory of the action of adsorbed oxygen in increasing the viscosity of clay suspensions is supported by the observed effect of the incorporation of air into suspensions treated with wetting agents and such reagents as sodium oleate. It was noticed

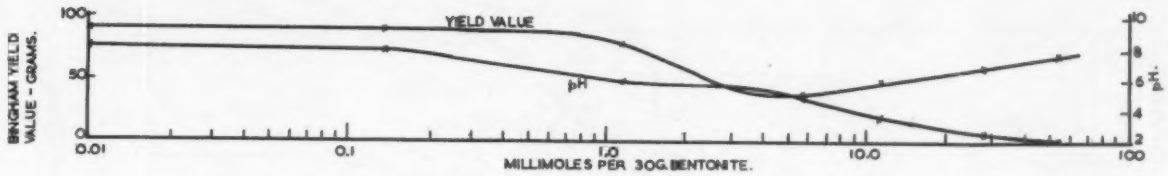


Fig. 5 — The effect of the addition of Group 4 reagent on the yield value and pH of clay suspensions.

that air introduced by the stirring action of the viscometer noticeably increased the viscosity.

Pyruvic Acid Effect

Weiss (1955) observed that pyruvic acid had the capacity to reduce the viscosity of clay suspensions to a marked extent. The results of the addition of this reagent to clay suspensions are summarised in Fig. 3. Since pyruvic acid is an α ketonic acid, it is capable of co-ordinating metal cations by chelation. The progressive lowering of viscosity could be due to the formation of co-ordination complexes, while the subsequent increase in viscosity may be due to their precipitation.

Alternatively, the behavior of this reagent in reducing the viscosity may be due to partial coagulation and the destruction of the colloidal suspension, eventually causing water separation. The compound is a moderately strong acid and hence markedly decrease the pH of the suspension. These results agree with those reported by previous investigators. It is felt that the mechanism of the changes involved differs from those associated with the use of the "photographic developer" type of reagent.

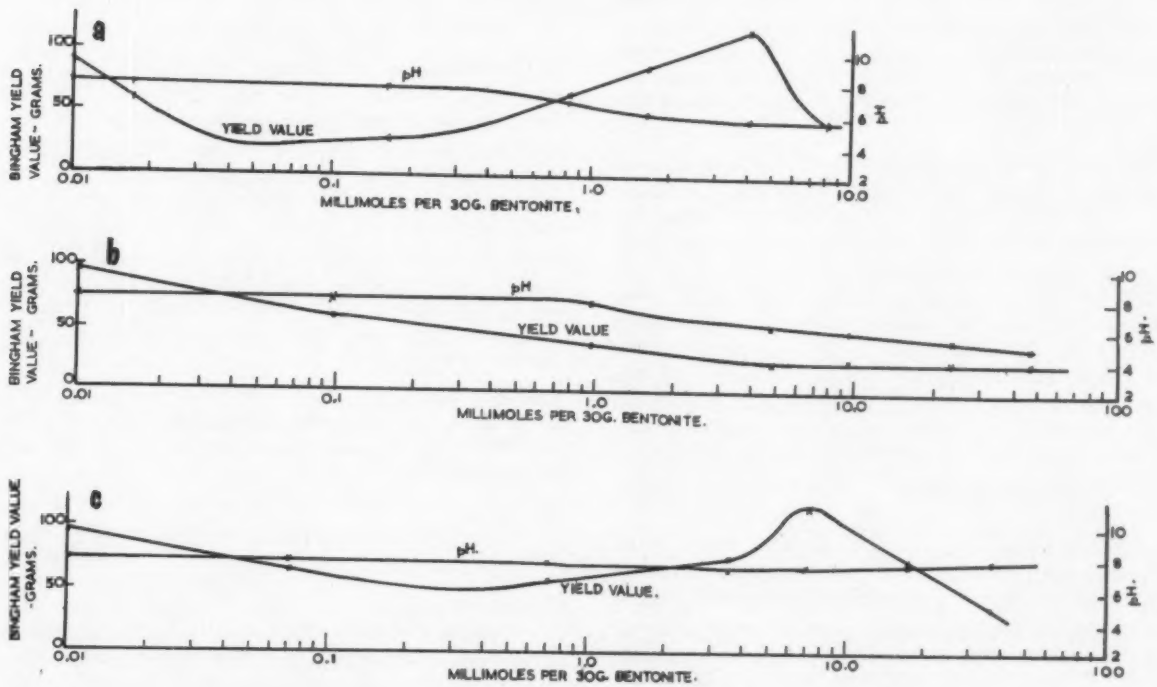
Finally, it was proposed to study the effect of large anions of high polarisability such as phosphates.

The first reagent used was sodium di-hydrogen phosphate, and the results are shown in Fig. 5. The reagent reduced both the pH and the viscosity of the suspensions. Di-sodium hydrogen phosphate had practically no effect on the pH, but did produce a slight "peak" in the viscosity curve. Tri-sodium phosphate, due to alkaline hydrolysis, was responsible for a gradual increase in pH, but produced a marked "peak" in the viscosity curve.

Sodium pyrophosphate completely changed the character of the bentonite suspensions. They developed a glue-like consistency which was not observed in any of the suspensions treated with other reagents. Sodium hexa-metaphosphate at first reduced the viscosity but then increased it until a "peak" was developed; the pH, however, was steadily reduced.

Nature of Reagent Action

In an endeavor to ascertain the nature of the action of these reagents on the clay lattice, separate samples of the clay, previously treated with the var-



(Fig. 6 — continued on next page)

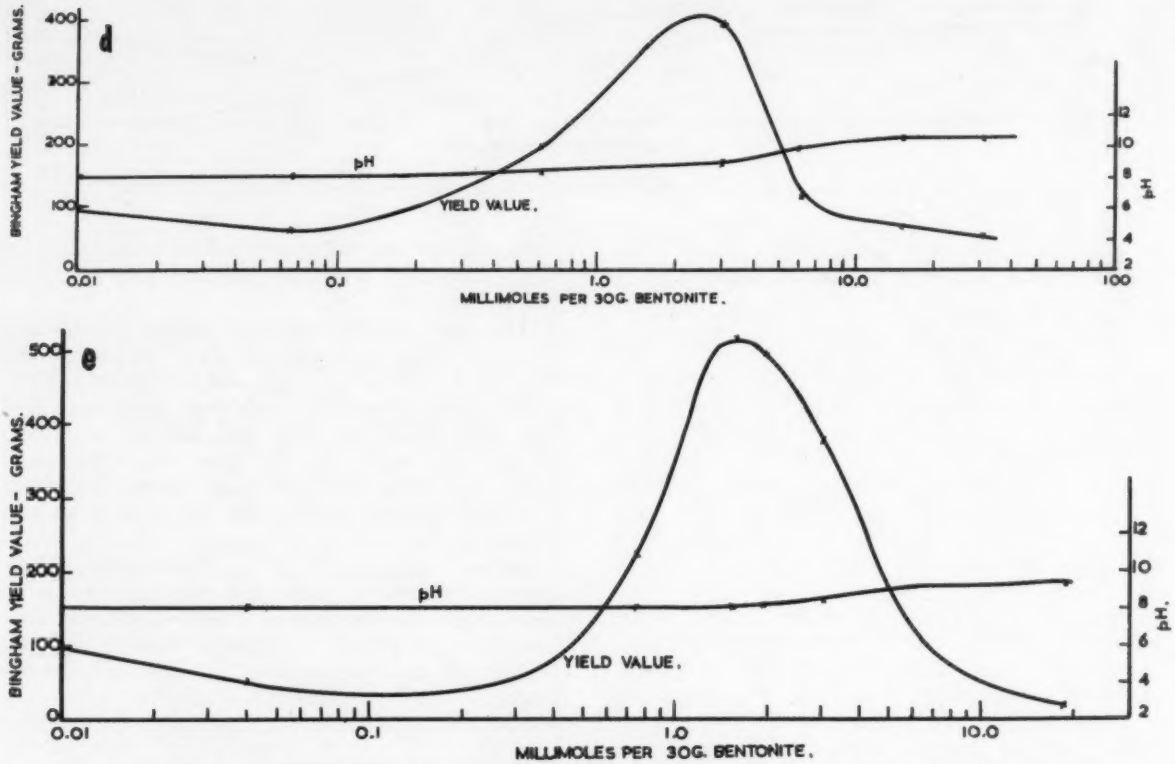


Fig. 6 — The effect of the addition of Group 5 reagents on yield value and pH of clay suspensions. (a) hydrated sodium hexa-meta phosphate, (b) hydrated sodium dihydrogen ortho phosphate, (c) hydrated disodium hydrogen ortho phosphate and (d) hydrated tri-sodium ortho phosphate and (e) hydrated sodium pyrophosphate.

ious phosphates, were investigated. The treated clay suspensions were thoroughly washed with distilled water, settled by centrifuging, and the wash water tested with ammonium molybdate for the presence of phosphates. When the wash water was free of phosphate, portion of the treated clay residues were extracted with nitric acid and the extracts tested for phosphate.

In all cases the results were positive. The remainder of the treated clay samples were dried and subjected to differential thermal analysis, the results being shown in Fig. 6. It will be seen that the endothermal changes normally occurring at 160 and 730 C (320 and 1340 F) have been suppressed. Since these changes are due to the expulsion of the adsorbed and lattice water, respectively, it appears reasonable to assume that phosphate ions had replaced the water from these positions. In addition, the exothermal peak at 960 C is (1760 F) is almost completely suppressed, suggesting that the phosphate complex formed is stable up to temperatures of 1100 C (2012 F).

The intensity of the endothermal peak in the treated clay is greatest with sodium di-hydrogen phosphate and least with tri-sodium phosphate. This is explained by the fact that the concentration of available phosphate ions is inversely proportional to the replaceable hydrogen. Thus, by mass action the tri-sodium phosphate will cause the replacement of increased quantities of both inter-layer and lattice water, which is reflected in decreased endothermal reactions at both 160 and 730 C (320 and 1340 F).

EXPERIMENTAL

Determinations of viscosity were carried out on a rotational viscometer. The type used was a "Stormer," in which the modifications to cup and bob suggested by Lindsley and Fischer (1947-1950) were incorporated. For ease of manipulation of the viscometer, suspensions containing 10 per cent bentonite, 90 per cent water were used. To these suspensions were added the equivalent of 0.01, 0.10, 0.50, 1.00, 2.50, 5.00 and 10.0 g. of anhydrous reagent for 30 g. of bentonite. The reagents chosen were, as far as possible, sodium salts of the particular acid. The reagents added were:

Group I

Sodium salts of both weak and strong acids
acetate, carbonate, chloride, citrate, formate, sulfate and tartrate.

Group II

"Wetting-agents" of the sodium dodecyl benzene sulfonate type.

Group III

Organic and inorganic reducing agents, as well as salts of nonreducing agents. Sodium salts of gallic, succinic, benzoic, salicylic and oleic acids; resorcinol, catechol, hydroquinone, pyrogallic acid, o-,

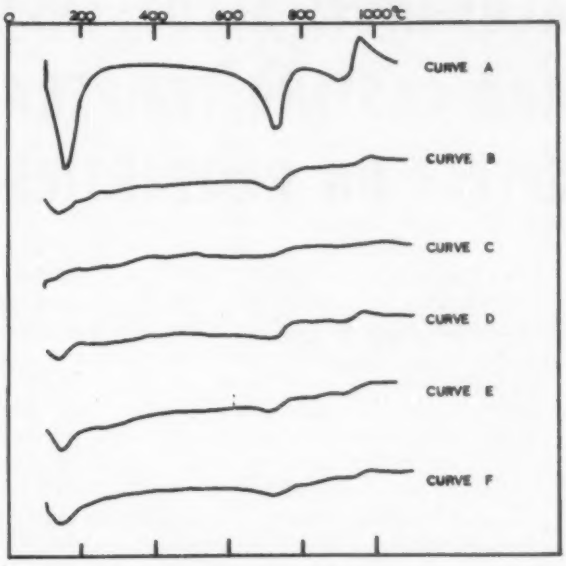


Fig. 7 — Differential thermal analysis curves for bentonite treated with various phosphates. All curves — Western Wyoming, Black Hills, bentonite. (A) untreated, (B) treated with sodium pyrophosphate, (C) treated with tri-sodium ortho phosphate, (D) treated with disodium hydrogen ortho phosphate, (E) treated with sodium dihydrogen ortho phosphate and (F) treated with sodium hexa meta phosphate.

m- and p- amino phenol; hydrazine sulfate, hydroxylamine hydrochloride, sodium hydrogen sulfite, sodium sulfite and pyruvic acid.

Group IV

Sodium salts of meta-, ortho-, and pyrophosphates.

The treated bentonite suspensions were allowed to stand 48 hr so that all exchange reactions would be completed. Viscosity determinations were carried out at varying rates of shear to permit the determination of a "Bingham yield value" (green and Weltmann, 1946). These yield values were then used as an index to viscosity, and were plotted against the amount of added reagent. The pH values of the treated suspensions were determined using a Cambridge Universal pH meter.

GENERAL CONCLUSIONS

The effects of the addition of the various types of reagents to clay suspensions may be summarized:

The salts of weak acids increase the viscosity of clay suspensions probably because of an interaction between the anion and the adsorbed cations which are replaced from the clay lattice by the sodium ions. This is probably followed by precipitation of the compounds formed, resulting in a decrease in viscosity.

Wetting agents of the dodecyl benzene sulfonate type do not affect the viscosity to any extent, but do assist in the dispersion of the bentonite during the preparation of the suspensions.

The "photographic developer" type of reagent reduces the viscosity of bentonite suspensions, presumably because of their reducing characteristics, which enable them to combine with oxygen adsorbed on to the clay particles, though they themselves are not adsorbed on to the clay lattice. Pyruvic acid reduces the viscosity of clay suspensions, possibly because of the formation, with adsorbed cations, of co-ordination compounds which later are coagulated.

Phosphates are adsorbed on to the clay lattice, resulting in the exclusion of interlayer and lattice water and stabilization of the complex to temperatures in excess of 1100 C (2012 F).

There is no direct relationship between viscosity and pH of the suspensions, since it is possible to increase or decrease the viscosity without altering the pH.

REFERENCES

1. "Scabbing Tendencies of Molding Sands," AFS Committee progress report, AFS Transactions, *vol. 57*, p. 400 (1949).
2. Barker, G. J. and Truog, E., *Journal of the American Ceramic Society, vol. 21*, p. 324 (1938).
3. Barker, C. J., "How Clay and Sand React to Soda Ash," American Foundryman, *vol. 26*, no. 6, p. 44 (1954).
4. Booth, G. H., "Sand Properties vs. pH," AFS Transactions, *vol. 57*, p. 210 (1949).
5. Diran, L. M. and Taylor, H. F., "The Nature of Bonding in Clays and Sand-Clay Mixtures," AFS Transactions, *vol. 60*, p. 356 (1952).
6. "pH Control of Foundry Sand," AF Roundtable, American Foundryman, *vol. 26*, no. 3, p. 34 (1954).
7. Fischer, E. K., *Colloidal Dispersions*, J. Wiley & Sons, N.Y. (1950).
8. Fischer, E. K. and Lindsley, C. H., *Journal Colloid. Sci., vol. 3*, p. 111 (1948).
9. Green, H. and Weltmann, R. N., *Industrial and Engineering Chemistry*, Anal. Ed., *vol. 18*, p. 167 (1946).
10. Green, H., *Journal of Physical Chemistry, vol. 13*, p. 611 (1942).
11. Kruyt, H. R. and Van Klooster, H. S., *Colloids*, 2 Ed., J. Wiley & Sons, London (1930).
12. Lewis, W. K., Squires, L. and Thompson, W., *A.I.M.M.E. Transactions, vol. 118*, p. 71 (1936).
13. Lindsley, C. H. and Fischer, E. K., *Journal of Applied Physics, vol. 18*, p. 988 (1947).
14. Markwell, P., "The pH of Moulding Sands," Exchange paper to the Institute of British Foundrymen, Victoria, from Institute of Australian Foundrymen, N.S.W. Div. (1954).
15. Pavlish, A. E., "Treatment of Bond Clays for Foundry Sand," AFS Transactions, *vol. 58*, p. 492 (1950).
16. Sharov, V. S., *Groznenskie Neftyanik, vol. 6*, no. 3, p. 10 (1936).
17. Weiss, W. J., *Chemical Abstracts, vol. 50*, p. 2155g (1955).
18. Zang, V. E. and Grott, G. J., "Casting Quality as Related to pH Value of Molding Sands," AFS Transactions, *vol. 62*, p. 393 (1954); American Foundryman, *vol. 25*, no. 3, p. 49 (1954).

ALUMINUM ALLOY TEST BAR CASTING TEMPERATURE EFFECT ON PROPERTIES

by J. W. Meier and A. Couture

ABSTRACT

After a recapitulation of the role of separately cast test bars in checking the melt quality and the response to heat treatment, a general review is presented on the effects of pouring temperature, maximum melt temperature and prolonged holding time on the properties of aluminum sand casting alloys. Separately cast test bars can be used successfully for melt quality evaluation only if they are cast under standardized and strictly controlled conditions. To accomplish this, they should be cast at the most suitable temperatures, independent of the pouring temperature of the production castings.

The aim of the present investigation was to evaluate the effect of various pouring temperatures on the mechanical properties, the grain size and the porosity (density) of separately cast test bars in six commonly used commercial alloys. Consideration was also given to the effects of overheating of the melt and of prolonged holding times at three temperature levels. The results showed that higher pouring temperatures affect markedly (although in varying degree) the properties of alloys C4, G10, S5 and SC51, but have little or no effect on alloys SG70 and ZG61. Overheating or prolonged holding times have no lasting effect on the properties of alloys S5, SC51, SG70 and ZG61, provided a proper pouring temperature is used. Properties of bars from overheated alloy C4 melts could not be completely restored, and no recovery whatever could be obtained for alloy G10 melts.

It is concluded that the maximum melt temperature and the pouring temperature for separately cast test bars in alloys C4 and G10 should not exceed 720 C (1330 F), if consistent and comparable results are to be expected. For the other alloys, the use of a standardized pouring temperature (or temperature range) is essential to ensure effective melt quality control.

INTRODUCTION

The perennial dispute over the usefulness of separately cast test bars for the evaluation of the quality of castings was discussed in an earlier paper.[1] It was emphasized that separately cast test bars are not intended to represent the properties of production castings and should be used only to check the melt quality, or the response to heat treatment, of the material of which the castings were made.

Table 1[1] illustrates the significance of test results obtained on the different kinds of test bars, as related to the properties of production castings. This table shows that there is no compromise: either separately cast test bars under strictly controlled casting procedure should be used (a) and assess the melt quality, or cut production castings into test bars (f) to check the actual properties of these castings. All other ways (b-e) are useless and, in most cases, misleading. Indeed, they are often detrimental to the quality of the production casting, because cast-on additions may change the solidification pattern and cause defective castings.

The designers and users of castings are, of course, interested only in the actual properties of the castings. Metallurgists and foundrymen generally agree that the only way to guarantee high quality and consistent properties of production castings is by strict control of all melting, casting and heat treating

TABLE 1 — CORRELATION OF TEST BAR AND CASTING PROPERTIES

Type of Test Bar	Are Test Bar Properties Correlated with: Melt Quality	Are Test Bar Properties Correlated with: Properties of Casting
a) Separately cast under controlled (standardized) casting conditions	Yes	No
b) Separately cast without control of casting variables	Unlikely	No
c) Joined to same sprue as casting	No	No
d) Cast on the casting	No	No
e) Machined from coupon cast on the casting	No	No
f) Cut out from the cast casting	No	Depends on casting design (thermal gradient) —in most cases, correlation is limited to section from which test bar was taken.

J. W. MEIER is Principal Met., Non-Ferrous, and A. COUTURE is Scientific Officer, Physical Met. Div., Mines Branch, Dept. of Mines and Technical Surveys, Ottawa, Canada.

(Published by permission of the Dir., Mines Branch, Dept. of Mines and Technical Surveys, Ottawa, Canada)

operations, and by checking the melt quality on test bars cast separately from the same melt as the production castings.

This is also the basis of international standardization of casting alloys, recently adopted by ISO/TC 79[2] at the June 1958 meeting at Harrogate, England. A free translation of part of Resolution 33 may be of interest:

> The mechanical properties of a casting are determined by the casting procedure used. For this reason it is practically impossible to use standard test bars (a) to reproduce the mechanical properties of the casting or (b) to represent general casting conditions applicable to all the different casting methods.
>
> That is why it is customary to establish the melt quality of the metal used to make the castings by determining the mechanical properties of separately cast test bars produced under strictly controlled conditions.
>
> In general, it is not expected that the mechanical properties obtained from such test bars will be reproduced in all parts of the castings that the test bars represent, because of complexity of shape, variation in wall thickness, location of risers or chills, etc. However, by special foundry techniques, it is often possible to obtain, in specified parts of the casting, mechanical properties approaching or even exceeding those of the separately cast test bar.
>
> The form and dimensions of test bars must be standardized, and the test bars must be cast under standard conditions including gating design.

It should be particularly stressed that the full value of melt quality evaluation can be achieved only if the test bars are cast under standardized and strictly controlled conditions. As shown earlier,[1] there are almost 50 variables affecting the results of mechanical tests on cast test bars. They are related to the alloy composition, melting conditions, casting procedure, casting design, heat treatment, test bar preparation and some testing variables.

The main purpose of this paper is to discuss one of the most important factors affecting the melt quality, namely, the pouring temperature. The full significance of this variable can be assessed only if the thermal history of the melt, especially the maximum melt temperature and the holding time, is known. These three variables are interdependent and have a cumulative effect on the properties of the castings. A considerable number of papers on this subject have been published in the past 50 years, and a selected list of references is given at the end of this paper.[3-22]

GENERAL CONSIDERATIONS

Pouring Temperature

Most foundrymen are aware of the importance of the proper choice and strict control of the pouring temperature. It is accepted that the best one for most aluminum alloys is the lowest temperature at which a sound casting can be produced and that, usually, the mechanical properties decrease with the increasing pouring temperature. There are some exceptions: for example, alloy ZG61* shows—as do most magnesium-base alloys—optimum tensile properties when poured at a temperature somewhat higher than the lowest possible;[12,21] Hurren[4] reports similar behavior for alloy CN42 ("Y" alloy).

There are numerous references on the effect of pouring temperature on the mechanical properties of aluminum casting alloys.[3-22] In most cases, the decrease of mechanical properties with rising pouring temperature has been attributed to the increase in grain size. A close correlation of mechanical properties with grain size has been reported for various alloys.[13,17,23]

Colton and LaVelle[20] do not believe that lower mechanical properties of castings are due to large grain size, and state that the decrease in strength and ductility is due to increased shrinkage and gas porosity caused by higher temperature. The large grain size, they say, is also caused by high temperature, but this is merely a concurrent phenomenon not the cause of poor properties. They found that test bars of equal soundness have equal properties, regardless of the grain size within a 10-15 fold range.

Ruddle and Cibula[22] state that in cast alloys of cubic structure the influence of grain size, per se, is negligible. Nevertheless, the mechanical properties are affected by the grain size, because of its influence on the shape and magnitude of the shrinkage voids, inevitably present to some extent in castings of long-freezing-range alloys. The effect of grain coarsening upon tensile properties may, therefore, be attributed to variation in the size and particularly in the shape of the voids, the increase in the total volume of voids being a minor factor.[17]

To overcome the effects of grain coarsening at higher temperatures, the use of more effective grain refiners has been recommended.[15-17,19]

Melt Temperature

The maximum melt temperature, i.e., the highest temperature reached by the molten alloy during the melting or refining operations, is considered as another important factor affecting melt quality. In general, it has been found that overheating of the melt is deleterious to the mechanical properties and grain size of aluminum casting alloys.[4-7,9,10,16,17,21,22] Cooling the melt down to a low pouring temperature may, in some alloys, restore partly or completely the properties of the casting. In more sensitive alloys (C4 and G10), a complete recovery of the melt quality can be achieved only by solidification (ingotting) and remelting.[5,9,10,12,16]

Quadt[14] reported that he never experienced deleterious effects of overheating on the properties of commonly used commercial casting alloys if a low pouring temperature was used. In the present investigation, this observation was confirmed for alloys S5, SC51, SG70 and ZG61. However, the recovery of alloy C4 melts was found to be incomplete (Fig. 2), and no recovery after overheating could be obtained for alloy G10 (Fig. 3).

Holding Time

It is always desirable that the holding time, i.e., the time the alloy is kept in the molten state before pouring, be as short as possible. In commercial foundry practice this cannot be consistently obtained, be-

*Designations of alloys and tempers used throughout the paper are according to C.S.A. Codes H.1.1-1958 (alloy designations) and H.1.2-1958 (temper designations).

cause of unforeseen delays in mold preparation, or similar operational shortcomings. It is essential, therefore, to know how such prolonged holding times, at various melt temperature levels, affect the properties of the castings.

Hurren[4] found that the effect of prolonged heating on tensile properties was only slight, but reported a greater influence on the resistance to repeated impact. Bossert[5] investigated holding times up to 24 hr and found that soaking at 715 C (1320 F) did not affect the melt quality. However, he found that soaking at 790 C (1455 F) resulted in considerable grain coarsening. Cibula[16] found that prolonged holding of a C4 melt at 760 C (1400 F) caused a marked grain coarsening, and reports that to restore the original grain size the melt had to be superheated to 975 C (1785 F), solidified and remelted.

Gas Content

The deleterious effect of gas content on the mechanical properties of aluminum alloy castings is well known,[24-27] and the necessity of a thorough melt degassing operation in the production of quality castings is today generally recognized. Chlorine, nitrogen and various proprietary compounds are used for degassing aluminum alloy melts at temperatures below 720 C (1330 F). Degassing should be continued until a gas content test, e.g., the commonly used reduced pressure solidification test, shows that the melt is substantially gas free.

An interesting additional aid in testing the gas content by quick determination of the density of a constant volume sample has recently been proposed by Sulinski and Lipson.[28]

POURING TEMPERATURE FOR TEST BARS

In considering the pouring temperature for separately cast test bars, it should be borne in mind that the only reason for using these test bars is to check the quality of the melt under standardized conditions. To accomplish this, test bars should be cast at the most suitable temperature, independent of the pouring temperature of the production castings. The proper temperature to provide the most effective solidification conditions for the test bars has to be established and standardized for each alloy composition.

Unfortunately, the choice of the casting temperature is sometimes limited by specification clauses; e.g., the U.S. Federal Specification QQ-A-60 lb (1957) requires that "the temperature of the metal while pouring test bars shall not be lower than 20 F (11 C) below the temperature at which the casting is poured." There is, however, an alternative requirement, that, if the pouring temperature of the castings is above 760 C (1400 F), specific approval must be obtained from the procuring agency.

Colton and LaVelle,[20] commenting on the above clause, remark that if all the properties in the specification are based on results from bars cast at a temperature of 675 C (1250 F), it will be difficult to obtain the same properties with metal poured at 760 C (1400 F). They propose, therefore, that if the castings are of such a shape or complexity that it is necessary to pour at 760 C (1400 F) or higher, the portion of metal that is left for test bars should be allowed to cool down to at least 705 C (1300 F) before the test bars are poured.

The purpose of the present investigation was to evaluate the effect of various pouring temperatures on the mechanical properties, the grain size and the porosity (density) of separately cast test bars in six commonly used commercial aluminum alloys. Additionally, consideration was given to the effects of overheating the melt and of holding times at three temperature levels.

EXPERIMENTAL PROCEDURES AND RESULTS

Materials and Procedures

Most of the melts prepared in the course of this investigation were made from commercial-quality alloy ingots, supplied to Canadian Standards Association (C.S.A.) Specification HA.3-1958 (Table 2). Exceptions to this were several alloy C4 melts which were prepared from higher purity aluminum ingots (99.85 per cent) with additions of commercial alloy hardeners. These melts were made for comparison purposes, and used in the study of holding times (Table 5).

The alloy ingots were melted down in an oil-fired furnace, using silicon carbide crucibles, and the melt sizes varied from 40 to 80 lb. No flux or grain refining additions were used. All melts were degassed by chlorine or nitrogen flushing (or a combination of both), at a temperature of 680 C (1255 F), until results of the reduced pressure solidification test indicated gas-free metal. After degassing, a 10 min settling time was allowed at the same temperature.

Test bars were cast to shape (Fig. 1) in green sand and tested without machining. This test bar design[29] is widely used in the magnesium industry, and is being employed in the experimental foundry for investigation on all aluminum and magnesium casting alloys (as well as on some copper-base alloys). Previous work[30] showed that this test bar design gives reliable and consistent results, and is more sensitive to melt quality variations than are any of the other test bar designs used in Great Britain or the U.S.A. The grain size gradient reported by Quadt for a similar four-bar design[13] has never been observed in any of the many

TABLE 2 — CHEMICAL COMPOSITION OF ALLOY INGOTS* PER CENT

Composition, %	Alloy Designation**					
	C4	G10	S5	SC51	SG70	ZG61
Cu	4.0-5.0	0.10	0.10	1.0-1.5	0.20	0.30
Fe	0.80	0.20	0.60	0.50	0.40	0.75
Mg	0.03	9.5-10.6	—	0.40-0.60	0.20-0.40	0.55-0.70
Mn	0.30	0.10	0.10	0.30	0.10	0.30
Si	1.2	0.20	4.5-6.0	4.5-5.5	6.5-7.5	0.25
Ti	0.20	0.20	0.20	0.20	0.20	0.15-0.30
Zn	0.10	0.10	0.10	0.10	0.10	5.0-6.0
Cr	—	—	—	—	—	0.40-0.60

Unless range is shown, single values are the maximum amounts permitted.
*According to C.S.A. Specification HA.3-1958.
**According to C.S.A. Code H.1.1-1958.

alloys used in our laboratories during the past 15 years.

Solution heat treatments (Table 3) were carried out in a circulating-air furnace heated electrically and controlled to ±2 C; boiling water was used as quenching medium. Aging treatments (Table 3) were carried out in an electric oven with air circulation and close temperature control (to ±1 C). ZG61 alloy bars were not heat treated and were tested after 21 days of room temperature aging.

Density measurements were made on the grip ends of the test bars. The density values given in the graphs and tables are averages from a series of measurements on a number of test bars cast for the various experimental conditions. It should be mentioned that the scatter of individual density values was surprisingly small, so that the average figures are truly representative of the condition.

In all graphs and tables, only average values of mechanical properties are given because scatter bands would unnecessarily obscure the picture. In all cases, the scatter of individual results was well within the limits expected for castings produced under controlled laboratory conditions.

Chemical Composition

To evaluate the effect of variations of pouring temperatures and holding times on the chemical composition of the alloys, two samples for chemical analysis were taken from each melt. One sample was taken from test bars cast in the first mold, and the other from test bars cast in the last mold.

The ranges of analytical results obtained from castings representing all melts are listed in Table 4. The results show that the first six alloy compositions were well within the specification limits. Alloy ZG61 had a slightly higher magnesium content and a somewhat low chromium content, but this did not affect the level of mechanical properties obtained in this investigation.

A close review of all results showed that the variations in pouring temperatures up to 820 C (1510 F), and in holding times up to 2 hr in this temperature range, had no significant effect on the chemical composition of any of the alloys investigated.

Pouring Temperature

Figures 2 to 7 illustrate the effect of variations of pouring temperature on the properties of separately cast test bars for six commercial aluminum casting alloys. The first series of results, as shown by the graphs presented on the left side, was obtained from melts with increasing pouring temperatures. The second series, as shown by the graphs on the right

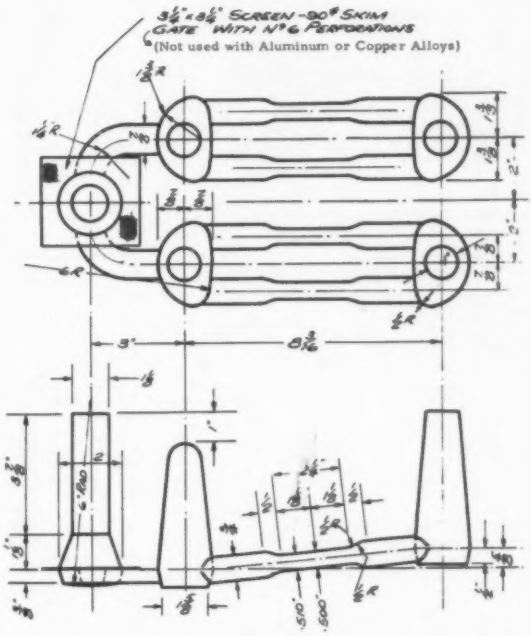


Fig. 1 — Test bar design according to U.S. Federal Specification QQ-M-56.

TABLE 3 — HEAT TREATMENTS AND PROPERTIES FOR SEPARATELY CAST TEST BARS*

Properties	Alloy Designation** C4-T6	G10-T4	S5-F	SC51-T6	SG70-T6	ZG61-F†
Heat Treatment						
Temp, C	515	435	—	525	535	—
Time, hr	16	20	—	16	16	—
Aging						
Temp, C	160	—	—	160	160	—
Time, hr	4	—	—	4	4	—
Minimum						
UTS, psi	32,000	42,000	17,000	32,000	30,000	32,000
0.2% YS, psi	20,000	22,000	—	20,000	20,000	22,000
Elong., % in 2 in.	3	12	3	2	3	3

*According to C.S.A. Specification HA.9-1958
**According to C.S.A. Codes H.1.1-1958 and H.1.2-1958
†Room temperature aged for 21 days

TABLE 4 — RANGES OF ANALYTICAL RESULTS, PER CENT

Alloy Designation*	Range, % Cu	Fe	Mg	Si	Ti	
C1**	4.69-4.76	0.37-0.38	—	0.75-0.78	0.11-0.12	—
C4X**	4.62-4.82	0.15-0.18	—	0.46-0.53	0.10-0.12	—
G10	—	0.12-0.17	10.09-10.58	0.06-0.10	0.01-0.01	—
S5	—	0.25-0.27	—	4.88-5.00	0.08-0.09	—
SC51	1.23-1.32	0.32-0.35	0.45-0.52	4.98-5.15	0.11-0.13	—
SG70	—	0.25-0.30	0.30-0.35	6.78-7.55	0.13-0.17	—
ZG61	0.15-0.19	0.44-0.47	0.65-0.75	Zn 5.22-5.68	0.12-0.16	Cr 0.27-0.46

*According to CSA Code H.1.1-1958
**C4 Commercial alloy ingots
C4X Alloy prepared from higher purity aluminum and commercial alloy hardeners.

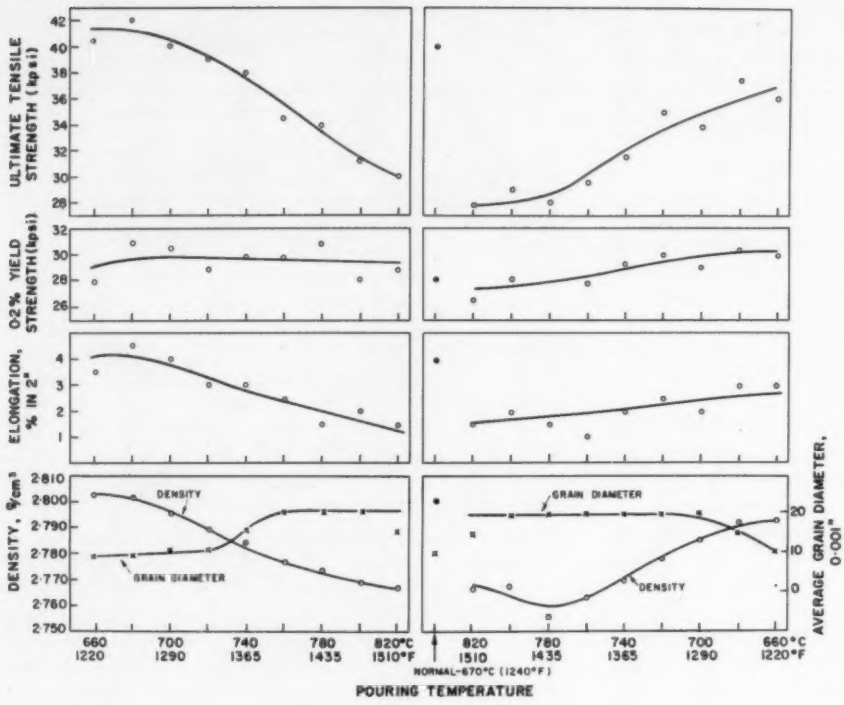


Fig. 2 — Pouring temperature effect on C4-T6.

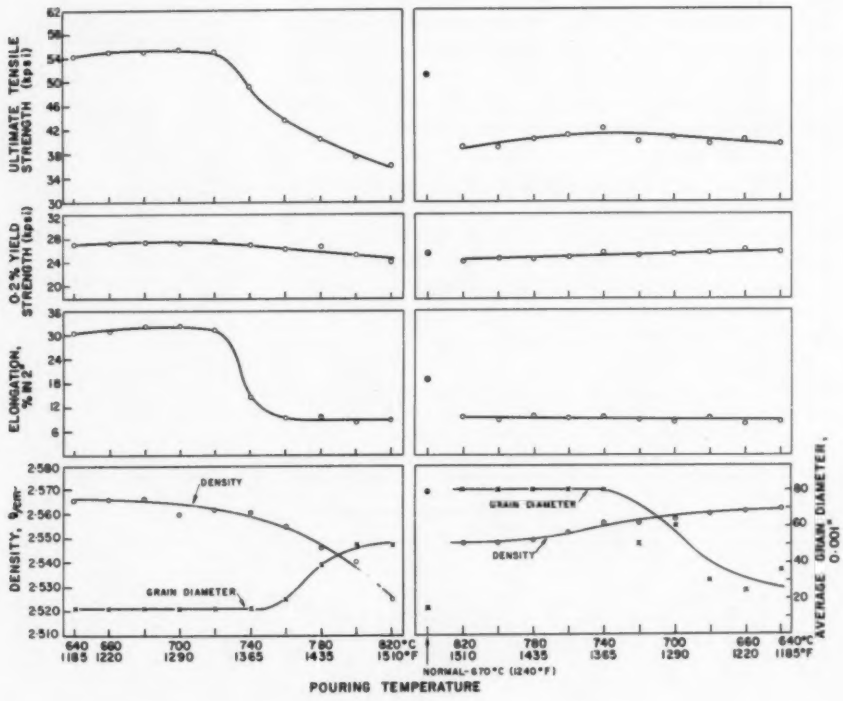


Fig. 3 — Pouring temperature effect on G10-T4.

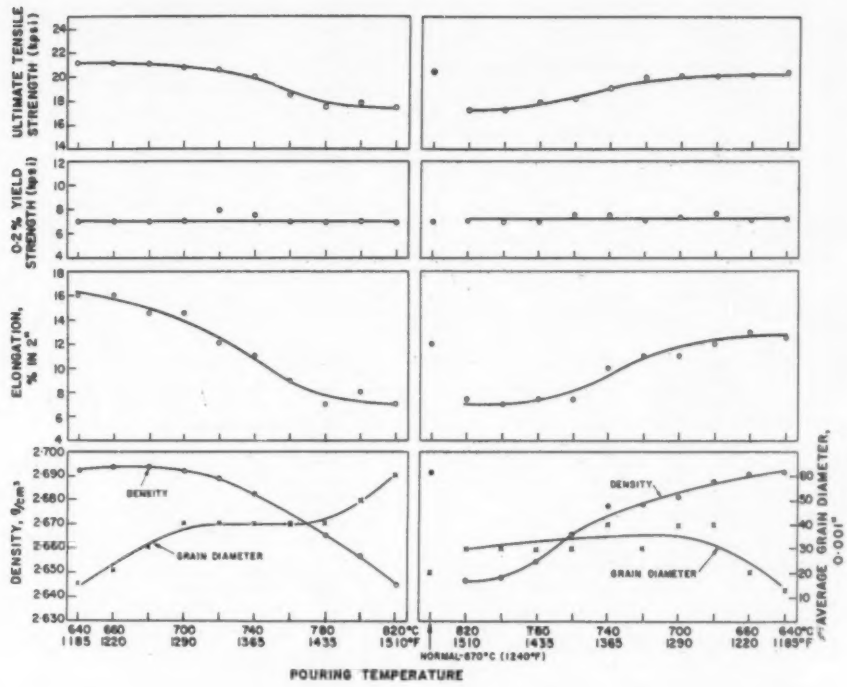


Fig. 4 — Pouring temperature effect on S5-F.

side, was obtained on melts with decreasing pouring temperatures.

The procedure followed in the first series was to melt down the ingots, heat the melt rapidly to 680 C (1255 F), and degas at that temperature. After a 10 min settling time the crucible was removed from the furnace, and after the melt has cooled down to the lowest pouring temperature (640 C or 660 C) the first four test bars (Fig. 1) were cast. The remainder of the melt was then returned to the furnace and heated to the next pouring temperature, and another set of test bars was cast. This procedure was repeated until the top temperature of 820 C (1510 F) was reached.

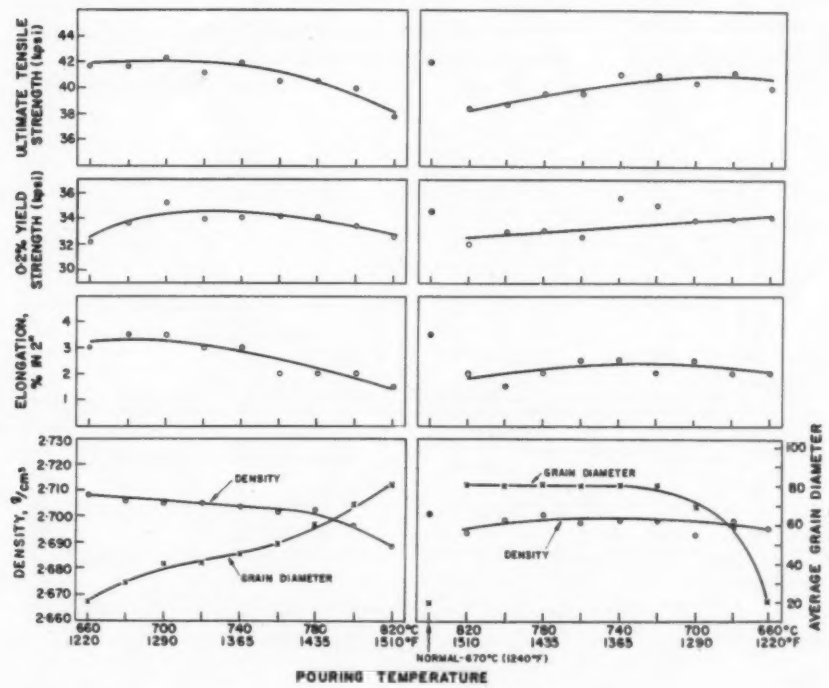


Fig. 5 — Pouring temperature effect on SC51-T6.

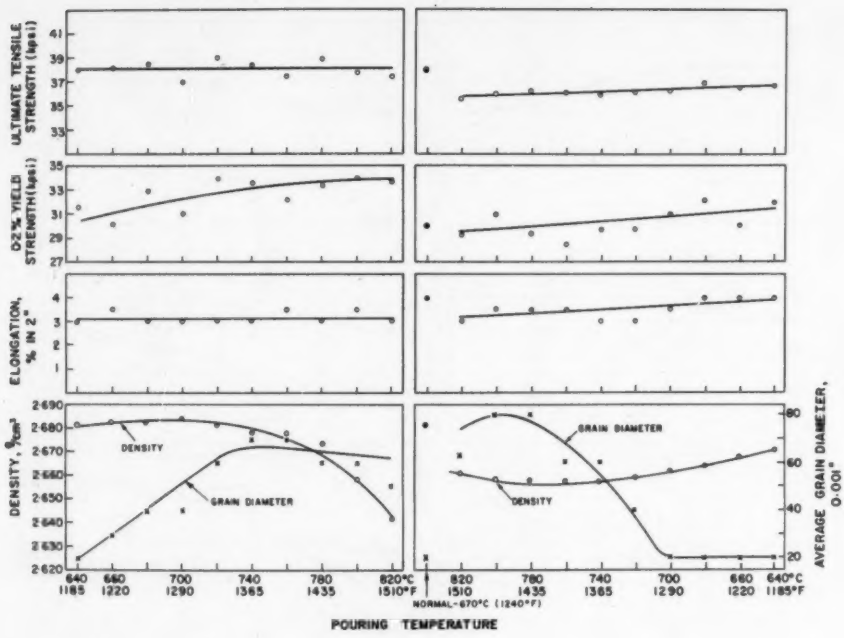


Fig. 6 — Pouring temperature effect on SG70-T6.

In the second series, the melt was degassed at 680 C (1255 F), and after a 10 min settling time at this temperature the first bars were cast at the normal pouring temperature: for the first five alloys, 670 C (1240 F); for alloy ZG61, 730 C (1345 F). The melt was returned to the furnace, heated to 820 C (1510 F), and removed from the furnace. The second set of test bars was cast immediately, and the next castings were made when the metal cooled down to the lower pouring temperatures (Figs. 2 to 7).

Holding Time

Tables 5 to 10 present the results on the effect of holding time, at three levels of temperature, on the properties of separately cast test bars for six commercial aluminum casting alloys. The melting procedure used in these series was similar to that used in the investigation on pouring temperatures. In the first series the alloy ingots were melted down, heated rapidly to 680 C (1255 F), degassed, and kept for 10 min to settle. The first test bars were cast at that temperature, and the melt was returned to the furnace and kept for 30 min at 680 C (1255 F) before casting the next test bars. This was repeated until a total holding time of 2 hr was reached.

In the second and third series, the same procedure was used for the first casting, then the metal was heated to the higher temperature (740 C or 800 C) and, after casting the second set of test bars immediately, kept at that temperature for the various holding times. After reaching the 2 hr holding time and casting the sixth test bar set, the melt was cooled down

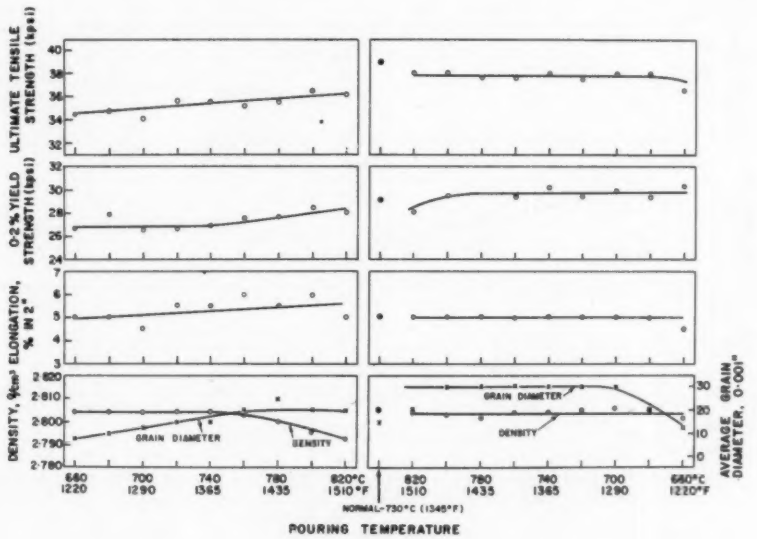


Fig. 7 — Pouring temperature effect on ZG61-F.

TABLE 5 — HOLDING TIME EFFECT (C4X-T6)

Pouring Temperature C	Pouring Temperature F	Holding Time, min	UTS*	YS*	E*	GS*	D*
680	1255	0	48.4	30.7	6.0	10	2.801
		30	46.4	31.3	5.0	10	2.802
		60	48.4	32.3	5.5	10	2.802
		90	46.7	32.1	5.0	10	2.802
		120	47.9	32.3	4.0	10	2.802
680	1255	0	47.7	30.9	8.0	8	2.800
740	1365	0	44.0	29.7	6.0	10	2.794
		30	45.0	30.4	6.5	15	2.790
		60	43.0	31.3	5.5	15	2.791
		90	42.7	31.4	5.5	15	2.792
		120	42.7	31.1	5.0	15	2.792
680	1255	0	43.4	30.9	6.0	12	2.797
		30	47.5	31.1	8.0	10	2.800
680	1255	0	46.6	31.0	6.0	10	2.798
800	1470	0	41.3	30.2	4.5	15	2.780
		30	38.4	30.4	3.0	18	2.776
		60	38.0	29.8	2.0	20	2.775
		90	39.8	29.5	3.5	20	2.774
		120	40.4	31.2	4.5	15	2.775
680	1255	0	40.0	32.0	3.5	12	2.790
		30	43.5	32.7	5.0	12	2.797

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

TABLE 7 — HOLDING TIME EFFECT (S5-F)

Pouring Temperature C	Pouring Temperature F	Holding Time, min	UTS*	YS*	E*	GS*	D*
680	1255	0	20.6	7.5	13.0	35	2.689
		30	20.8	7.7	14.0	35	2.691
		60	20.3	7.6	12.5	25	2.690
		90	20.5	7.6	13.0	30	2.691
		120	20.5	7.8	13.5	30	2.691
680	1255	0	20.6	7.4	14.0	25	2.692
740	1365	0	20.2	8.0	13.5	40	2.682
		30	20.2	7.4	14.0	30	2.682
		60	20.3	7.6	14.5	30	2.686
		90	20.2	7.1	13.0	30	2.687
		120	19.6	7.8	10.0	35	2.679
680	1255	0	20.2	8.0	12.0	30	2.681
		30	20.8	7.8	14.5	30	2.691
680	1255	0	20.5	6.7	15.0	35	2.691
800	1470	0	17.8	6.9	9.0	30	2.644
		30	17.3	7.1	8.5	60	2.645
		60	17.0	6.7	6.5	70	2.648
		90	17.6	7.4	7.0	80	2.662
		120	18.2	7.3	9.0	100	2.661
680	1255	0	20.0	7.4	13.0	70	2.690
		30	20.0	7.3	12.0	50	2.690

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

to the original pouring temperature of 680 C (1255 F). One test bar set was cast immediately, and another one after additional settling for 30 min. These last two castings were made to determine whether the original test bar properties (which in most cases decreased appreciably at the higher temperatures) could be restored by using a low pouring temperature.

TABLE 6 — HOLDING TIME EFFECT (G10-T4)

Pouring Temperature C	Pouring Temperature F	Holding Time, min	UTS*	YS*	E*	GS*	D*
680	1255	0	54.0	27.6	28.6	15	2.567
		30	54.6	27.9	30.4	15	2.567
		60	55.9	27.4	31.6	15	2.568
		120	55.2	27.0	32.2	15	2.568
680	1255	0	50.3	27.4	18.5	12	2.564
740	1365	0	49.4	26.8	15.0	15	2.560
		30	43.3	27.6	9.0	20	2.559
		60	42.2	26.2	7.5	20	2.560
		90	41.6	25.9	8.0	20	2.562
		120	41.5	26.3	9.0	20	2.563
680	1255	0	43.4	26.2	9.0	15	2.565
		30	42.5	26.0	7.5	15	2.565
680	1255	0	52.1	28.0	25.0	15	2.565
800	1470	0	36.5	25.8	8.5	50	2.534
		30	34.3	25.4	7.0	60	2.522
		60	33.2	25.3	7.0	60	2.528
		90	33.4	25.6	7.5	70	2.527
		120	34.2	25.9	6.0	80	2.534
680	1255	0	38.0	27.1	9.0	70	2.548
		30	38.5	25.9	8.0	50	2.556

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

It should be mentioned here that the 10 min settling time, used in all melts after the degassing operation, was not included in the holding times listed in Tables 5 to 10.

Melt Temperature

The effect of overheating the melts to 820 C (1510 F) on the properties of separately cast bars is

TABLE 8 — HOLDING TIME EFFECT (SC51-T6)

Pouring Temperature C	Pouring Temperature F	Holding Time, min	UTS*	YS*	E*	GS*	D*
680	1255	0	41.2	33.3	3.0	20	2.707
		30	40.7	33.8	3.0	20	2.705
		60	40.7	34.4	3.0	20	2.705
		90	41.2	34.6	2.5	30	2.708
		120	41.8	34.9	3.0	20	2.707
680	1255	0	41.4	33.2	2.5	20	2.708
740	1365	0	40.0	33.2	3.0	30	2.704
		30	40.8	34.2	2.0	30	2.700
		60	40.2	32.8	2.5	30	2.701
		90	39.9	33.0	2.5	30	2.700
		120	39.2	33.5	3.0	30	2.697
680	1255	0	39.1	33.2	3.0	20	2.700
		30	38.0	34.0	2.0	20	2.700
680	1255	0	41.8	34.1	2.5	30	2.706
800	1470	0	38.2	32.8	2.0	50	2.690
		30	34.2	29.8	2.0	80	2.670
		60	34.8	30.1	2.0	100	2.678
		90	34.3	30.3	2.0	120	2.677
		120	33.4	30.4	1.0	120	2.681
680	1255	0	39.0	32.5	3.0	30	2.693
		30	40.3	32.0	3.0	30	2.709

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

TABLE 9 — HOLDING TIME EFFECT (SG70-T6)

Pouring Temperature C	Pouring Temperature F	Holding Time, min	UTS*	YS*	E*	GS*	D*
680	1255	0	38.4	30.5	3.0	30	2.680
		30	38.0	32.2	3.0	20	2.680
		60	38.0	32.3	3.0	20	2.679
		90	37.7	33.5	4.0	20	2.680
		120	38.0	32.9	3.0	20	2.679
680	1255	0	37.5	30.0	3.5	30	2.681
740	1365	0	37.1	30.4	3.5	40	2.680
		30	36.4	28.9	3.5	50	2.674
		60	35.8	28.8	3.5	60	2.668
		90	36.6	27.6	4.5	70	2.671
		120	36.2	28.6	4.5	80	2.669
680	1255	0	35.8	30.3	4.0	20	2.669
		30	36.2	31.3	3.5	30	2.677
680	1255	0	36.2	30.1	3.0	30	2.680
800	1470	0	36.4	29.3	3.0	50	2.674
		30	34.8	27.6	3.0	60	2.658
		60	34.6	26.4	3.0	60	2.656
		90	33.8	27.3	3.0	60	2.645
		120	34.5	28.5	3.0	60	2.655
680	1255	0	35.5	28.6	3.0	20	2.667
		30	36.1	29.7	4.0	30	2.680

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

TABLE 10 — HOLDING TIME EFFECT (ZG61-F)

Pouring Temperature C	Pouring Temperature F	Holding Time, min	UTS*	YS*	E*	GS*	D*
680	1255	0	36.4	25.4	4.0	15	2.803
		30	36.9	25.3	5.0	15	2.802
		60	36.2	25.6	5.0	15	2.805
		90	36.8	25.4	4.0	15	2.805
		120	36.4	25.6	4.0	15	2.803
680	1255	0	35.8	26.3	4.0	15	2.803
740	1365	0	36.6	26.5	5.0	15	2.804
		30	36.4	26.2	4.5	30	2.804
		60	36.2	27.4	5.0	30	2.802
		90	35.7	27.8	4.5	30	2.805
		120	37.0	27.5	5.0	30	2.804
680	1255	0	36.5	27.9	4.5	20	2.805
		30	34.4	27.6	4.0	15	2.802
680	1255	0	35.8	26.3	3.5	15	2.803
800	1470	0	37.8	25.4	5.0	20	2.798
		30	36.3	25.4	6.0	30	2.797
		60	36.4	27.6	5.0	30	2.793
		90	35.6	28.4	5.0	30	2.794
		120	37.0	27.4	5.5	20	2.790
680	1255	0	35.6	26.3	4.0	15	2.800
		30	35.0	27.4	4.0	15	2.799

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

illustrated in the graphs on the right side of Figs. 2 to 7.

The combined effect of overheating and prolonged holding time on the properties of separately cast bars is shown in Tables 5 to 10.

Cast Plates

To check results obtained on separately cast test bars, four melts of alloys C4X, G10, SG70 and ZG61, respectively, were sand-cast into 4½ x 6 x ½ and 4½ x 6 x 1½-in. plates. In each case the melt was held for 10 min at the normal pouring temperature of the alloy before pouring the first series of castings. The melt was returned to the furnace, heated to 800 C (1470 F), and held at this temperature for 15 min. After pouring a second series of castings at 800 C (1470 F), the melt was cooled down to the normal pouring temperature and held at this temperature for 30 min before pouring the third series of castings.

Tables 11-14 present the results obtained on separately cast test bars and on test bars machined from the plates. Some of the tensile property results from cast plates, especially in alloys G10 and SG70, were below average values obtainable for such castings. A repetition of these melts was considered unnecessary, because the variations of the properties, due to changes of the melt temperature, confirmed the trends noted in the evaluation of separately cast test bars.

RESULTS

Al-4 Per Cent Cu Alloy (C4 and C4X)

The marked effect of increasing pouring temperatures on the properties of alloy C4-T6 test bars is shown in Fig. 2. Increasing pouring temperatures are responsible for a steady decrease of ultimate tensile strength, elongation and density, as well as for grain coarsening. The right-hand graphs clearly demonstrate that considerable deterioration of tensile properties is caused by overheating the melt to 820 C (1510 F), and that only a partial recovery of the melt quality can be achieved by cooling down to a low pouring temperature. It should be noted that the right-hand graphs indicate only a partial recovery of the mechanical properties and the density, in spite of the complete recovery of the grain size.

Table 5 shows the effect of holding time at three temperature levels on the properties of C4X-T6 (higher-purity alloy) test bars. Holding up to 2 hr at 680 C (1255 F) has no effect on the properties. Holding the melt at 740 C (1365 F) slightly affects the test bar properties. A full recovery can be achieved by lowering the melt temperature and holding the melt for some time at this temperature before pouring.

TABLE 11 — MELT TEMPERATURE EFFECT (C4X-T6)

Type of Casting	Pouring Temperature C	Pouring Temperature F	UTS*	YS*	E*	GS*	D*
Separately	680	1255	48.8	31.0	7.0	8	2.796
cast test	800	1470	43.9	31.8	6.5	15	2.777
bars	680	1255	46.8	33.5	7.0	10	2.794
½-in.	680	1255	44.6	31.4	7.5	8	2.786
thick	800	1470	36.6	28.4	3.0	12	2.762
plate	680	1255	43.5	30.0	7.5	8	2.783
1½-in.	680	1255	35.4	27.5	3.0	8	2.785
thick	800	1470	26.1	23.1	2.5	15	2.751
plate	680	1255	35.0	26.9	2.5	10	2.778

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

TABLE 12 — MELT TEMPERATURE EFFECT (G10-T4)

Type of Casting	Pouring Temperature C	Pouring Temperature F	UTS*	YS*	E*	GS*	D*
Separately	680	1255	52.9	27.5	27.5	15	2.562
cast test	800	1470	40.1	28.0	8.0	40	2.556
bars	680	1255	41.6	29.1	8.0	40	2.260
½-in.	680	1255	35.7	27.4	7.0	15	2.562
thick	800	1470	28.3	24.4	3.5	40	2.553
plate	680	1255	32.0	26.3	5.5	30	2.558
1½-in.	680	1255	33.7	24.5	7.0	20	2.547
thick	800	1470	28.9	21.9	7.0	40	2.513
plate	680	1255	30.1	23.1	6.0	40	2.521

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

Holding at 800 C (1470 F) causes a serious decrease in test bar properties, similar to that shown in Fig. 2. Lowering the melt temperature, and holding the melt at a low temperature, restored the melt quality only partly, although the density returned to its original value.

Table 11 lists the results obtained on cast plates. Although the recovery of the original properties is almost complete, it should be noted that in this experiment the exposure of the melt to the high temperature was much shorter than in the earlier experiments (Fig. 2 and Table 5) and higher purity metal was used.

It should be added here that during the present investigation it was found that C4 alloy melts prepared from high purity metals were much less sensitive to higher temperatures than those made from commercial ingots. A similar observation was also made on G10 alloy melts, but the difference was less pronounced and full recovery of melt quality after overheating was never obtained.

TABLE 13 — MELT TEMPERATURE EFFECT (SG70-T6)

Type of Casting	Pouring Temperature C	Pouring Temperature F	UTS*	YS*	E*	GS*	D*
Separately	680	1255	36.2	28.5	3.5	15	2.681
cast test	800	1470	37.4	28.6	5.0	50	2.680
bars	680	1255	37.4	28.5	5.0	15	2.681
½-in.	680	1255	33.2	29.4	2.0	15	2.678
thick	800	1470	33.2	29.2	2.5	60	2.676
plates	680	1255	34.1	28.6	3.5	15	2.678
1½-in.	680	1255	31.2	28.2	1.5	30	2.674
thick	800	1470	27.2	27.0	1.0	60	2.664
plates	680	1255	30.1	26.8	2.0	20	2.679

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

TABLE 14 — MELT TEMPERATURE EFFECT (ZG61-F)

Type of Casting	Pouring Temperature C	Pouring Temperature F	UTS*	YS*	E*	GS*	D*
Separately	730	1345	36.8	26.4	5.0	20	2.809
cast test	800	1470	38.5	26.2	5.5	20	2.808
bars	730	1345	38.4	26.4	5.5	20	2.808
½-in.	730	1345	32.9	26.4	4.5	15	2.801
thick	800	1470	33.7	26.7	4.5	15	2.795
plates	730	1345	31.9	24.8	4.0	15	2.790
1½-in.	730	1345	29.9	25.1	2.5	20	2.790
thick	800	1470	29.7	24.7	3.0	20	2.778
plates	730	1345	29.9	25.1	3.0	20	2.791

*UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E — Elongation in 2 in., %
GS — Average Grain Diameter in 0.001 in.
D — Density in g/cm³

It should be noted here that during the present investigation it was found that C4 alloy melts prepared from high purity metals were much less sensitive to higher temperatures than those made from commercial ingots. A similar observation was also made on G10 alloy melts, but the difference was less pronounced and full recovery of melt quality after overheating was never obtained.

Al-10 Per Cent Mg Alloy (G10)

The left-side graphs in Fig. 3 show that the properties of aluminum casting alloy G10-T4 are not affected by pouring temperatures below 720 C (1330 F). Above this temperature, and especially above 740 C (1365 F), the ultimate tensile strength, elongation and density values decrease rapidly, accompanied by a marked grain coarsening.

The right-side graphs illustrate the effect of overheating the melt to a high temperature 820 C (1510 F) and pouring at successively lower temperatures. Although the density and, to a greater degree, the grain size show improvement at lower pouring temperatures, the tensile properties remain unchanged at the low level caused by overheating.

The same pattern of behavior is shown in Tables 6 and 12. Holding the melt at higher temperatures causes a marked decrease in ultimate tensile strength and elongation. The melt quality cannot be restored by cooling down to a low pouring temperature, and no significant improvement could be obtained by prolonged holding at low temperature 680 C (1255 F). It should be noted (Table 6) that in the melt held at 740 C (1365 F) the grain size showed some improvement and the density was fully restored, and in the melt held at 800 C (1470 F) the density was appreciably improved. In both cases, however, this had little effect on the tensile properties.

Al-Si Alloy (S5, SC51, SG70)

As may be seen from Fig. 4 and Table 7, the properties of alloy S5-F test bars are significantly affected by variations in the pouring temperature and by holding at 800 C (1470 F), but complete recovery from the ill effects of overheating can be achieved by cooling down the melt to a low pouring temperature.

Figure 5 and Table 8 demonstrate a similar behavior for alloy SC51-T6, although the decrease in properties at higher pouring temperatures is much less pronounced.

Figure 6 shows no significant effect of melt or pouring temperature variations up to 820 C (1510 F) on the tensile properties of alloy SG70-T6 test bars, in spite of marked changes in density and especially in grain size. Table 9 shows a slight decrease in tensile properties after holding the melt at 800 C (1470 F), but they are completely restored at low pouring temperature. Table 13 shows a similar trend in results obtained on cast plates.

In the case of alloys S5 and SC51, a decrease in mechanical properties is usually accompanied by an increase in grain size and a decrease in density, al-

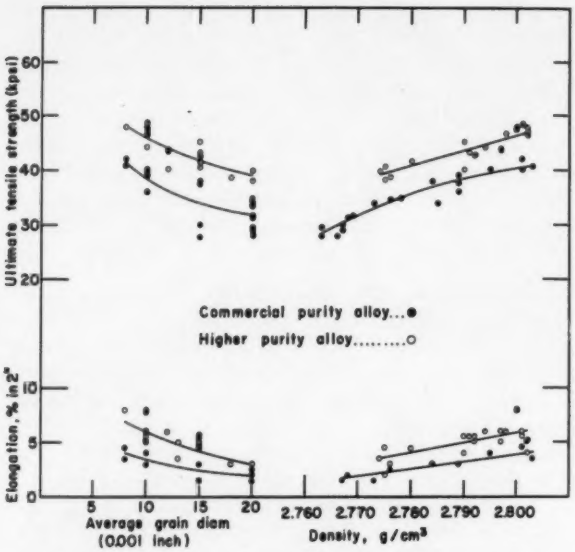


Fig. 8 — Comparison of mechanical properties with grain size and density of C4-T6.

though a deterioration of the grain size and density is not always followed by a similar decrease of the tensile properties.

Al-Zn-Mg Alloy (ZG61)

The results presented in Fig. 7, and Tables 10 and 14, demonstrate that the tensile properties of alloy ZG61-F are not affected by variations of melt or pouring temperatures between 720 C (1330 F) and 820 C (1510 F), in spite of small changes in density and grain size. Tensile properties of test bars cast below 720 C (1330 F) seem to be somewhat lower, which is in agreement with published data.[11]

Grand[18] reports that this alloy is susceptible, at low melt temperatures, to partial loss of chromium and titanium and recommends, therefore, the use of a pouring temperature above 710-720 C (1310-1330 F). This would account for the somewhat low chromium content obtained for some melts (see Table 4).

Mechanical Properties vs. Grain Size and Density

Figures 8 and 9 present the correlation of mechanical properties of alloys C4 and G10 with grain size and density (porosity). In the case of alloy C4, separate curves show also the effect of purity of the metal, although the trend of the curves is the same for both purities. In comparing these graphs, it should be noted that different scales were used because of the greater range of results obtained for alloy G10.

These two graphs indicate that the ultimate tensile strength and the elongation decrease appreciably with increasing grain size and decreasing density. The curves for alloy G10 show that its properties decrease more rapidly than those of alloy C4, and attain a critical point beyond which practically no further decrease of tensile properties can be observed.

The relation of mechanical properties with grain size was illustrated graphically in earlier publications, both for alloy C4[17] and for alloy G10.[23] The graphs shown in these publications are similar to those presented here (Figs. 8 and 9), although the results obtained differ considerably, mainly because of the difference in the range of properties encountered.

Similar correlations were found for alloy S5. Alloy SC51 shows a correlation between mechanical properties and density, but no correlation with grain size. There appeared to be no correlation of mechanical properties with grain size or density for the alloys insensitive to melt overheating (SG70, ZG61).

A close examination of all results obtained in this investigation (Tables 5-14 and Figs. 2-9) shows that a decrease in mechanical properties is usually accompanied by an increase of the grain size and a decrease of the density. On the other hand, as was already noted in the discussions of the individual alloys, in many cases a change in the grain size or the density is not necessarily followed by a similar change of the mechanical properties.

It seems, therefore, that even in the alloys which are highly sensitive to the effects of melt overheating

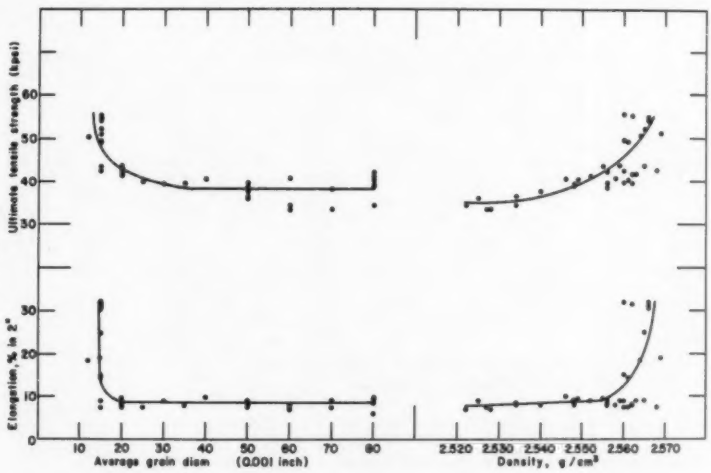


Fig. 9 — Comparison of mechanical properties with grain size and density of G10-T4.

(C4 and G10), the mechanical properties of castings produced from overheated melts are affected by factors other than density (shrinkage and gas porosity) and grain size. This may involve the reaction of trace elements, residual impurities, gases, etc., at higher temperatures to produce or eliminate compounds or effects not present in melts prepared at lower temperatures.

CONCLUSIONS

The results of the present investigation may be summarized in the following conclusions:

1) Higher pouring temperatures affect markedly, although in varying degree, the properties of aluminum casting alloys C4, G10, S5 and SC51, and have little or no effect on alloys SG70 and ZG61.
2) Overheating or prolonged holding times have no lasting effect on the properties of aluminum casting alloys S5, SC51, SG70 and ZG61, provided a proper pouring temperature is used. Cooling down the overheated melts and using a low pouring temperature did not completely restore the properties of aluminum casting alloy C4, and no recovery whatever could be obtained for alloy G10.
3) Maximum melt temperatures and the pouring temperature for separately cast test bars in alloys C4 and G10 should not exceed 720 C (1330 F), if consistent and comparable results are to be expected (It seems, therefore, evident that, at least in the case of these two alloys, the proposal[20] to cast test bars at the end of the casting operation, after cooling down the remaining part of the melt (overheated because of complexity or shape of castings) to a lower pouring temperature, would not be effective). For the other alloys, especially for S5 and SC51, the use of a standardized pouring temperature (or temperature range) is essential to ensure effective melt quality control.
4) A general correlation of mechanical properties with grain size and density has been shown graphically for alloys C4 and G10, which are highly sensitive to the effects of melt overheating, although it was noted, in some cases, that improvement in grain size or density is not necessarily accompanied by similar increase of mechanical properties of the casting.
5) No correlation of mechanical properties with grain size or density could be established for alloys that are relatively insensitive to the effects of melt overheating.
6) It seems that even in the alloys which are highly sensitive to the effects of melt overheating (C4 and G10) the mechanical properties are affected by factors other than density (porosity) and grain size.

REFERENCES

1. J. W. Meier, "The Effect of Various Factors on the Mechanical Properties of Magnesium Alloy Castings," *Proc. 25th International Foundry Congress*, Liege, Belgium, p. 223 (Sept. 1958).
2. International Organization for Standardization, Technical Committee 79 on Light Metals and Their Alloys, document ISO/TC 79-154. Committee TC 79 consists of representatives of [illegible]n active member-countries (incl. Canada and the U.S.A[illegible]d of 20 "observer"-countries (June 1958).
3. H. W. G[illegible]dett, "The Influence of Pouring Temperature on Aluminum Alloys," *Proc. 8th International Congress of Applied Chemistry, vol. II*, p. 105 (1912).
4. F. H. Hurren, "The Influence of Casting Temperature of Aluminum Alloys," *Proc. Inst. British Foundrymen, 17*, p. 459 (1923-24).
5. T. W. Bossert, "Effect of Melting and Pouring Conditions upon the Quality of No. 12 Aluminum Alloy Sand Castings," AFA TRANSACTIONS, *36*, p. 427 (1928).
6. T. D. Stay, E. M. Gingerich and H. J. Rowe, "Stronger Aluminum Castings by Improved Foundry Practice," AFA TRANSACTIONS, *38*, p. 65 (1930).
7. H. J. Rowe, "The Effect of Foundry Variables on the Mechanical Properties of Sand-Cast Tension Test Specimens," *A.S.T.M. Procedures, 38*, p. 242 (1938).
8. A. J. Murphy, S. A. E. Wells and R. J. M. Payne, "The Effect of Melting Conditions on Light Alloys," *Proc. Inst. British Foundrymen, 32*, p. 133 (1938-1939).
9. K. R. Van Horn and H. J. Heath, "Quality Control of Aluminium Alloy Aircraft Castings," *SAE Journal, 42*, p. 4 (1938).
10. S. A. E. Wells, "Metallurgical Factors of Importance to the Practical Aluminium Founder," *Proc. Inst. British Foundrymen, 36*, p. 215 (1942-1943).
11. H. Brown, "Development and Properties of Sand-Cast Aluminium Alloy Having High Strength After Ageing Without Previous Heat Treatment," AFA TRANSACTIONS, *52*, p. 1037 (1944).
12. E. Carrington, *Aluminium Alloy Castings*, C. Griffin & Co. Ltd., London, p. 222 (1946).
13. R. A. Quadt, "Effect of Certain Elements on Mechanical Properties of 1% Cu, 5% Si and 0.5% Mg Aluminium Sand Casting Alloys," AFA TRANSACTIONS, *54*, p. 465 (1946).
14. R. A. Quadt, discussion to paper by T. W. Bossert and H. J. Rowe, in "Non-Ferrous Melting Practice," A.I.M.E., p. 110 (1946).
15. W. E. Sicha and R. C. Boehm, "Effect of Titanium on Grain Size and Tensile Properties of an Al-4.5% Cu (No. 195) Casting Alloy," AFS TRANSACTIONS, *56*, p. 398 (1948).
16. A. Cibula, "The Mechanism of Grain Refinement of Sand Castings in Aluminum Alloys," *J. Inst. Metals, 76*, p. 321 (1949-1950).
17. A. Cibula and R. W. Ruddle, "The Effect of Grain Size on the Tensile Properties of High-Strength Cast Aluminium Alloys," *J. Inst. Metals, 76*, p. 361 (1949-1950).
18. L. Grand, "Study of Foundry Alloy A-Z5G," *Rev. Aluminium, 30*, p. 385 (1953).
19. H. Bernstein, "Investigation of the Grain Coarsening Behavior of Some Aluminum Alloys," *A.I.M.E. Transactions, 200*, p. 603 (1954).
20. R. A. Colton and D. L. LaVelle, "Test Bars for Copper and Aluminium Alloy Castings," *Foundry, 82*, (1954).
21. A. V. Carless, "Metallurgical Control of Quality in the Production of Aluminium Alloy Castings," *J. Inst. Metals, 85*, p. 227, disc. 518-534 (1956-1957).
22. R. W. Ruddle and A. Cibula, "Metallurgical Principles of the Control of Quality of Non-Ferrous Castings," *J. Inst. Metals, 85*, p. 265, disc. 518-534 (1956-1957).
23. A. L. Mincher, "Effect of Beryllium on D.T.D.300," *Metal Industry, 76*, p. 435 (1950).
24. L. R. Carr, "Investigation of the Mechanical Properties to be Expected in D.T.D.304 and D.T.D.298 Sand Castings and the Correlation of these Properties with Radiological Evidence," *Metallurgia, 28*, p. 142 (1943).
25. L. R. Carr, "The Quantitative Interpretation of Radiographs in Terms of Mechanical Properties," *J. Sci. Instruments, 23*, p. 221 (1946).
26. R. Jay and A. Cibula, "Influence of Magnesium Content on Layer Porosity and Tensile Properties of Sand-Cast Aluminium Alloys, B.S.1490-LM10 and B.S. (aircraft) L.53," *Proc. Inst. British Foundrymen, 49*, p. A125 (1956).
27. I. J. Feinberg, "Tensile Properties of Porosity-Graded 195 Alloy," *Non-Destructive Testing, 15*, p. 168 (1957).
28. H. V. Sulinski and S. Lipson, "Sample for Rapid Measurement of Gas in Aluminum," AFS TRANSACTIONS, *67*, p. 56 (1959).
29. U.S. Federal Specification QQ-M-56, p. 6, Fig. 1A (1950).
30. J. W. Meier and others — Unpublished work.

MOLTEN METAL HANDLING IN DIE CASTING PLANTS

by Victor D. Sweeney

ABSTRACT

The various ways metal is transferred in die casting plants are discussed. Special emphasis is placed on the use of centrifugal pumps for this purpose. Wherever possible illustrations are from actual operations. The discussion includes the various types of ladles used and how they are mounted. Siphoning and gravity feed by launder are described. Pump construction and use are discussed.

INTRODUCTION

The handling, transporting and pouring of liquid metal is an important phase of the foundry operation. This becomes more apparent in casting processes which are highly automated, such as the die casting operation. Metal consumption at the die casting machine can be so large that liquid metal is transferred from the melting furnace to an auxiliary and from there to the machine pot. Yet a large liquid metal requirement is by no means the sole reason for separate breakdown or central melting. When ingot is charged directly to the die casting machine pot, the chill produces uneven casting temperatures. Segregation also results, which is pronounced in aluminum alloy.

For example: the most common aluminum die casting alloy SC 84 which is nominally 3½ per cent copper with 8 to 9 per cent silicon. This alloy also contains high melting constituents which impart desirable casting characteristics, but these cannot be brought into solution below 1300 F. Since the casting temperature used for this alloy rarely is as high as 1200 F, these high melting constituents being heavier drop to the bottom of the pot without ever being in solution. The product at the bottom is sludge.

Metal transfer is often a manual operation, but it is heavy work in an uncomfortably hot situation and may not be too well nor too cheerfully performed. To ease this situation a number of methods of transferring liquid metal from furnace to receptacles automate this phase of making castings quite successfully.

OPEN HEARTH AND SIPHON

Open hearths are usually tapped, but the furnace must sit high if a ladle is to be placed under the tap hole. Taps are slow and can be troublesome—even hazardous. Tilting furnaces are sometimes employed. These are nearly always electric. A tilting furnace must sit pretty high for convenient manual working. In addition, they are somewhat expensive. Most users seem to be satisfied, but several pumps have been sold for emptying these tilting furnaces in case of failure of either mechanism or power.

In the die casting industry the use of the siphon (Fig. 1) seems to be confined to zinc alloy. This process is successful in quite a few plants. The knack to be learned is how to start the siphoning action. The siphon itself is nearly always a U-shaped tube. Usually it is made of stainless steel and is small in diameter. This U-shaped tube is completely immersed in the pot and held by a pair of tongs. While still in the metal, an elongated ladle is placed over one end of the tube. This end is quickly taken over the side of the pot into a ladle. The operation is slow. A pump replacing a siphon performed the operation in one-sixth the time—seconds instead of minutes. This operation looks hazardous. The pipe tends to plug up.

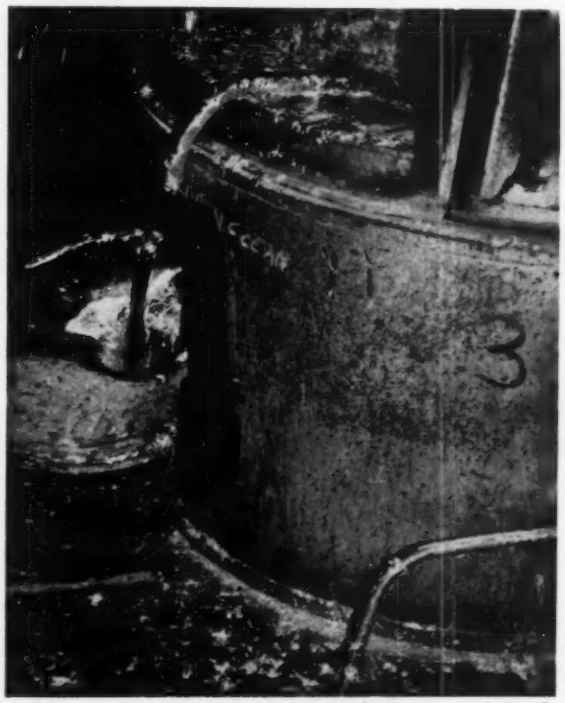


Fig. 1 — Operating siphon.

V. D. SWEENEY is with Metal Pumping Services, Inc., Cleveland.

Fig. 2 — Ladle with long handle.

Sometimes the only means of transfer is the ladle itself. A ladle with a long handle is suspended from a trolley (Fig. 2). This ladle is swung into the zinc alloy pot and partially filled by turning. It is carried down the line of machines, and the handle is convenient for tilting the ladle to feed the machine pots. There are also the stoppered ladles (Fig. 3). These are practical when hoods over the pots are not required. These ladles are immersed in the zinc alloy pots. The stoppers or sliding vane valves are opened to fill the pots at the machines. A real drawback is drip, which is a characteristic, unless they are new or kept in constant repair.

ZINC ALLOY TRANSFER

There is a process for zinc alloy in limited use which eliminates all molten metal traffic. This is all electric and all refractory. The central melting furnace tilts to fill a reservoir which is connected to a trough or launder (Fig. 4). The die casting machines are lined up on either side so that they are connected to the launder. The reservoir, the launder and the machine furnaces then have one common metal level. The metal in the launder is prevented from freezing by covers which contain resistance heating elements. Add the fact that this is a 100 per cent refractory installation which keeps dross losses to a minimum due to the lack of pick-up from iron, and you combine two extremely appealing features—low metal loss and no liquid metal traffic.

Needless to say, an installation of this type is expensive, nor is this the only drawback. For one thing, this is a zinc alloy installation, and none of it will convert to aluminum as the demand shifts. The whole operation must be kept molten all the time, even when no machines are operating on evening shifts, weekends and holidays. If anything happens to any part, the whole operation must be shut down. The launder cuts the aisle which limits all traffic, and could get in the way of some kinds of machine repairs. Still, users seem well satisfied.

Molten metal is not only carried in ladles by hand and by trolley; lift trucks with tilting devices frequently carry ladles (Figs. 5, 6). The usual method

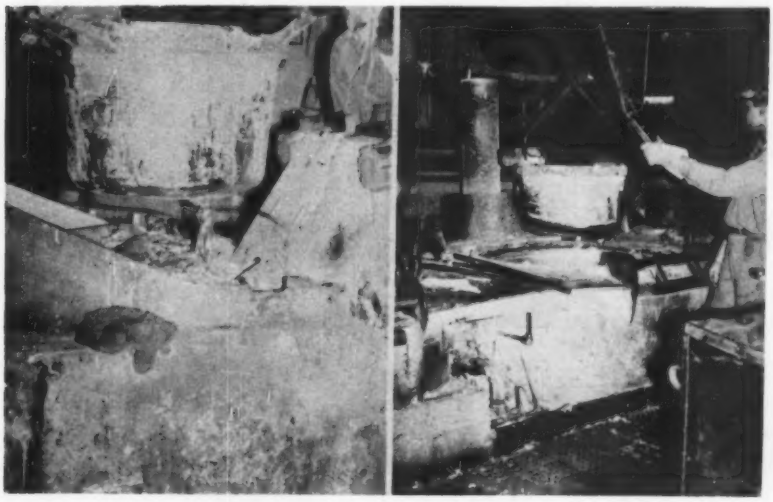


Fig. 3 — Stoppered ladle.

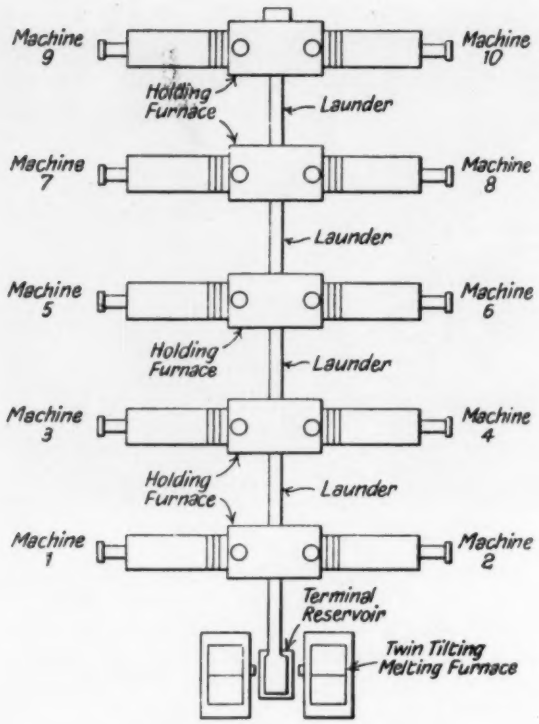


Fig. 4 — Gravity feed launder.

is to tilt the metal from the side (Fig. 5), using the standard lift truck tilting mechanism. Sometimes there is not sufficient room for this method. A lift truck can be mounted with a ladle so that it can tilt forward (Fig. 6). A pump, of course, may be easily mounted on gas-electric trucks to transfer from the ladle to the machine pot. Time is an important element in filling these larger ladles whether they are mounted on lift trucks or carried on trolleys. Pumps are frequently used to fill such ladles. This is especially true of zinc base alloy because the problem of attack from liquid metal is not severe. There is no particular problem in this respect for lead or magnesium. Recently pumps have been employed successfully for transferring aluminum and its alloys.

BULK TRANSFER

The pumps which are used for bulk transfer of liquid metal have one thing in common; they are all centrifugal in action. Pumps chosen for this work vary in capacity from 500 to 2000/min. There is probably no practical limit to capacity. Much larger pumps are in actual use, but not in foundries for the purpose of transferring metal.

The pumps for aluminum alloy (Fig. 7) are constructed of refractory or ceramic materials so that no metal is in contact with the molten aluminum. Refractory materials, of course, do not approach the strength of metals causing somewhat bulkier design. There is an imposing and growing list of materials which can be considered for pump parts. In use at the present time are graphite, clay graphite, silicon-nitride-bonded silicon carbide, fused quartz, synthetic fiber and castables. The resultant pump is more sturdy than one would expect, and is designed to remain in an aluminum bath for indefinite periods of time.

Pumps for zinc alloy, most lead and magnesium alloys are usually constructed of ferrous alloys (Fig. 8). In the case of magnesium, the attack on iron is so slight on nickel free irons or steel that warpage from temperature gradients is about the only problem. Zinc alloy is much more erosive, but this poses no problem unless high temperatures are encountered. Certain of the the stainless group and alloy irons (Fig. 8) have proved satisfactory.

Particular attention must be paid to the parts which are immersed. This attention should include design as well as the materials used. Attack from molten zinc alloy is, of course, a function of temperature. This becomes especially noticeable when temperatures exceed 900 F. The higher the temperature, the greater the temperature gradient between the molten metal and the surface above. This could cause temporary or even permanent misalignment. In die casting practice, however, high temperatures are rare, and the author personally has never had to deal with high temperature as a source of trouble. If temperatures do not exeed 900 F, a pump should go a long time without repair.

PUMP POWER

Pumps are powered by three different means — electric, fluid and air motors. Electric and air motors are common, but there are few if any fluid motors used on centrifugal pumps in die casting plants, although hydraulic pressure is available at every machine, and the small amount used by a pump would never be missed. This operation of these motors seems to be quite satisfactory.

The use of electric motors is widespread. The employment of an electric motor is certainly indicated when a pump is used in a bull ladle, for otherwise a compressor must also be carried. Needless to say, their operating cost is lower than either fluid or air motors. Yet electric motors are usually special, heavy

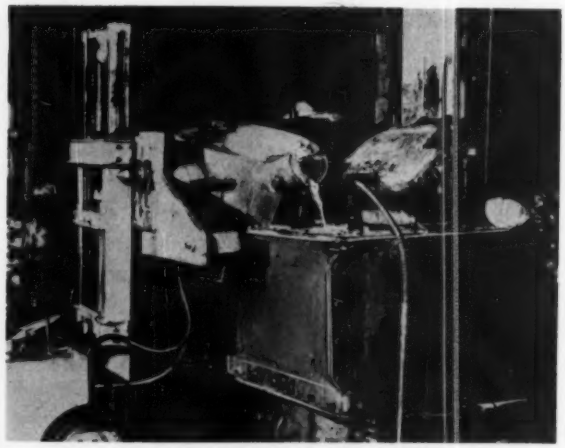


Fig. 5 — Side tilting ladle on lift truck.

Fig. 6 — Forward tilting ladle on lift truck.

and bulky on account of the temperature problem. They tend to make the pump top heavy. They will operate at only one speed and may require a gear reducer.

Air motors, in the author's company's opinion, are the best general answer for powering pumps, especially the comparatively small ones used in the die casting industry. Air motors are light, small but reliable. Stalling does not hurt them, and the pump output is readily controlled by varying the air pressure. They are self-cooling and will run in considerable heat.

The pumps used by zinc alloy manufacturers may be on wheels and are bulky because they must carry metal from the bottom of a big alloying pot to the pouring ladle. Other pumps meant for more versatile use may be quite compact. As explained before, it is simple to make a temporary pipe extension where added distance is required. The more simple the pump, the less there is to go wrong with it. They start readily, as they do not have the mass to carry the heat away and so cause freezing.

There are a few refractory pumps running in zinc alloy. They wear exceedingly well. Replacement of parts has been due to breakage. The ones familiar to the author are about three years old and look like

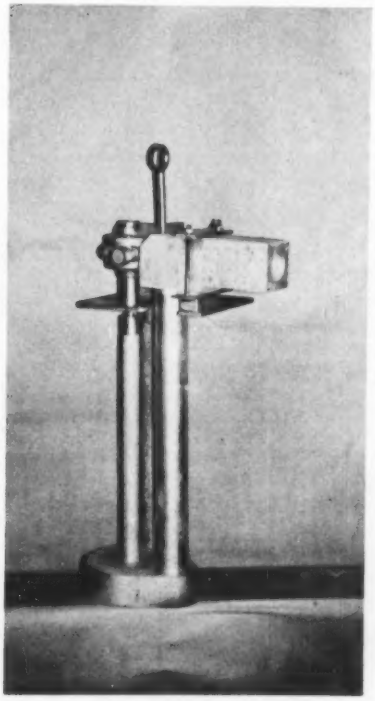


Fig. 7 — Refractory pump for aluminum.

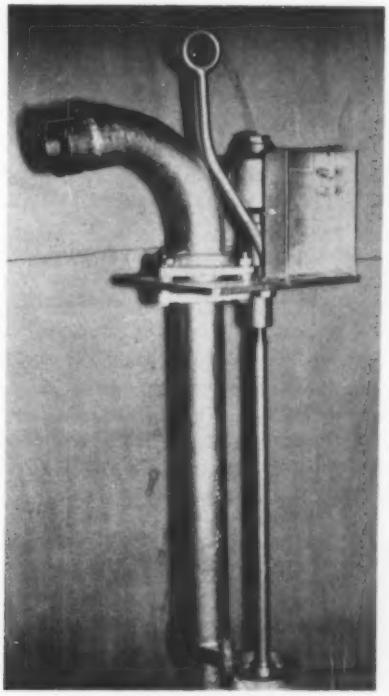


Fig. 8 — Alloy iron pump.

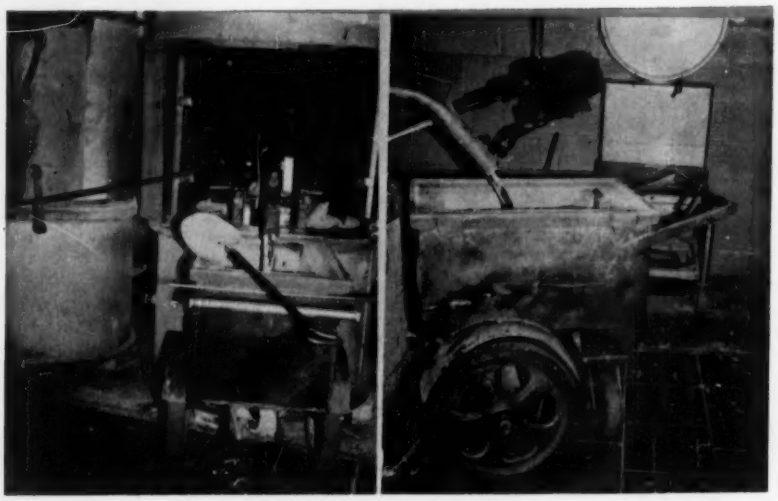


Fig. 9 — Pump filling ladle.

they may run indefinitely. Of course, a refractory pump will stand much higher temperatures which are occasionally wanted in running down certain type scraps. There is a safety factor in the use of centrifugal pumps in the die casting foundry. The pump may be operated from a safety position by using a button or valve so constructed that metal flows only when pressure is applied. The recognized hazards of the tape-hole siphon or heavy hand ladling are eliminated.

PUMPS FOR DIE CASTING

Pumping certainly affords the most versatile method of transferring molten zinc alloy. It obviates gravity in determining the height of any of the equipment. Pumps will handle practically any volume.

Here are some of the uses to which pumps are put in the die casting foundry. Molten metal is transferred from the melting or alloying pot to the ladle (Figs. 9, 10). In this instance the pump itself is largely hidden by the discharge pipe. The pipe is not part of the pump, but is hung loosely over the spout. It is put on and removed by the handle at the top. This reduces a dimension which makes the pump portable. The pump is simply pulled out by a man and placed in the next pot.

One of the ladles used is of 5000 lb capacity. It is fed by pumping from the alloy pot. The discharge pipe has a swivel which permits feeding the line of machines on either side of the aisle. Many zinc die castings are of good weight and the production so great that the machine pot does not have sufficient holding capacity. Auxiliary pots are placed along side. The operator gets the metal for this machine pot by pressing a button or lever which accentuates the pump in the auxiliary pot (Fig. 11).

In vacuum die casting of aluminum, there is an equivalent. The pot or furnace should be kept at close level. When the castings are large, pumps are sometimes employed to provide molten metal from an auxiliary source. Pumps, of course, are commonly employed to transfer metal from furnace to furnace, from scrap pot to alloy pot, and so forth. Their safety factor, speed and convenience are not the sole factors here. They make possible locating furnaces and pots at the proper level for convenient working and cleaning.

COLD CHAMBER WORK

There is another field particularly in cold chamber work in which the centrifugal pump at least so far has not been employed. Of course, there is a large amount of hand ladling to the cold chamber. A ladle of the proper size is selected. Seasoned operators can time their shot well, and the process can lead to satisfactory casting results. Large casting weights, how-

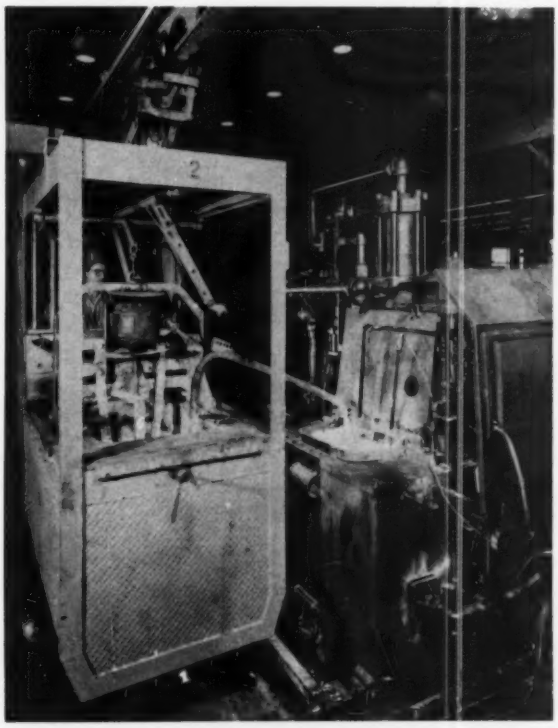


Fig. 10 — Pumping from large ladle.

ever, lead to fatigue, and perfect timing on each shot makes for still better results. To this end, a number of different methods have been employed.

Nineteen years ago one die casting company began using a mechanical ladle. This ladle rests in the holding pot. When it is raised out of the pot to the proper level, it contents run down a sleeve into the cold chamber. This is not particularly to save labor, but to permit automatic timing which speeds up the process of making sound castings. Maintenance is largely preventive, so downtime is small. The chief drawback is the difficulty of maintaining a dross free surface, and the ladle must rise through the surface.

More than 10 years ago came the electro-magnetic pump. On the whole, this works well, and it delivers an accurate quantity of metal from below the surface of the furnace. Initial expense and a little extra maintenance caused this pump to be largely superseded by the low pressure air type (Fig. 12). In this case, low pressure air is employed to force metal from a closed chamber through an orifice to the cold chamber. The quantity poured is controlled by an automatic time cycle. In one case the time cycle is varied according to the metal level in the closed chamber. The chamber, of course, has to be opened to replenish the metal poured, but such chambers may be fairly large, and this may not have to be done too frequently. Another manufacturer replaces the metal by vacuum after each shot.

In either case, the metal is taken from beneath the surface and delivered to the cold chamber with very little agitation. This method also permits very close timing, and there are quite satisfactory reports from the field. Cost may be a considerable drawback, especially where small machines and castings are involved.

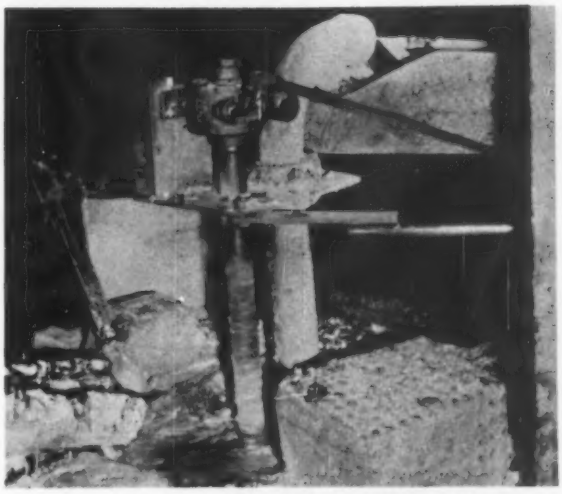


Fig. 11 — Pumping from auxiliary pot.

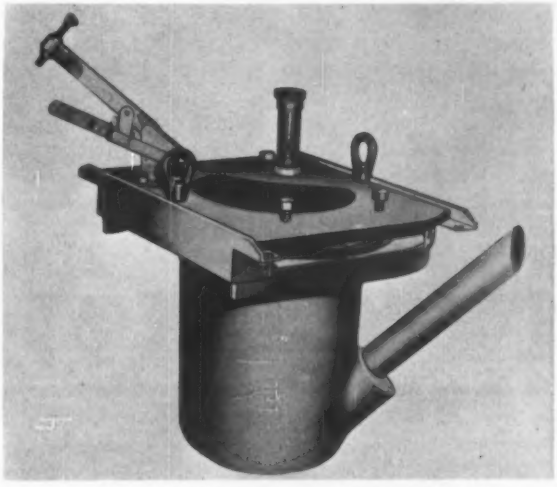


Fig. 12 — Low pressure air automatic ladle.

Automatic Metering

Not suitable for aluminum, but apparently satisfactory for magnesium, is an automatic metering mechanism (Fig. 13). In this case, the metal in the

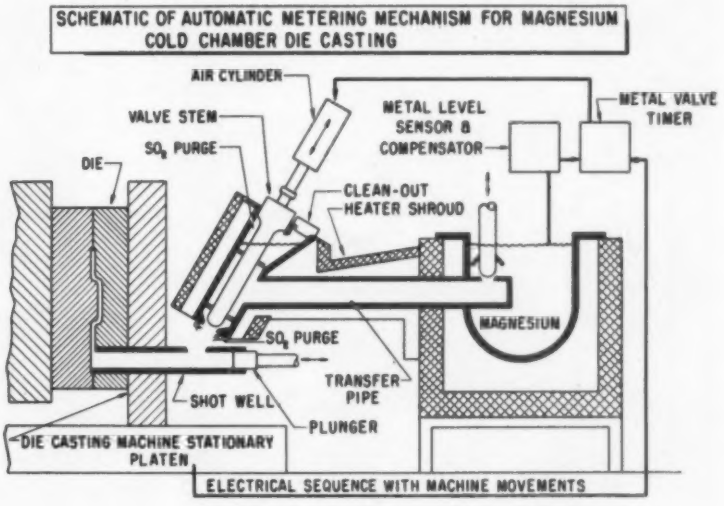


Fig. 13 — Automatic metering device.

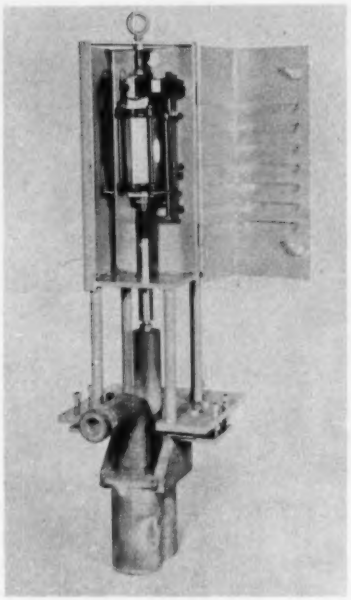


Fig. 14 — Ball check piston pump.

valve stand pipe is directly connected to the holding pot so that their level is the same. The valve is opened for a definite time cycle which controls the amount of metal delivered to the cold chamber. A ball check piston pump (Fig. 14) has been proposed to meter the metal going to the cold chamber. In this case, the shot could be directly controlled by the number of piston strokes as the piston makes positive displacement of aluminum. The operation of a pump of this type has been observed, but no reports have come from this type of application.

If vacuum casting of aluminum really takes hold, this problem of the proper quantity of timed metal to the cold chamber may be solved by utilizing the vacuum to induce the metal into the cold chamber. A hole is made in the bottom of the cold chamber. A tube with suitable orifice extends into the metal bath below. When vacuum is applied metal is sucked into the cold chamber. The plunger crosses the orifice at the proper time and continues to make the shot. The excess metal in the tube drops back to the bath.

This, however, gives rise to a problem of build up in the sucker tube. The tube itself must obviously be air tight, and is usually constructed of iron. Protective washes are applied on the outside. The inside is often lined with synthetic refractory fiber. Constant improvements are being made, and sucker tubes are not now too unsatisfactory, even though they are subject to considerable maintenance. As noted before, the metal level in the hold pot should be closely held. This is sometimes accomplished by ladling or pumping from an auxiliary source (Fig. 15).

It is possible that a centrifugal pump would provide a satisfactory means of introducing molten metal to the cold chamber when the shots are large. Probably some kind of temperature sensing apparatus could control the quantity accurately.

CONCLUSION

In conclusion, as the die casting process becomes automated, the molten metal handling problem multiplies. Fortunately, there are a number of ways to solve this problem so that the manufacturer can select the method which is most economical and best suited to his location and plant layout. Safety in bulk transfer is receiving more attention and should be a prime consideration in any change involving bulk handling.

It is sometimes desirable to eliminate hand ladling to the cold chamber machine. This may be accomplished in a number of ways, but only the process using low pressure air has wide field experience involving any considerable period of time.

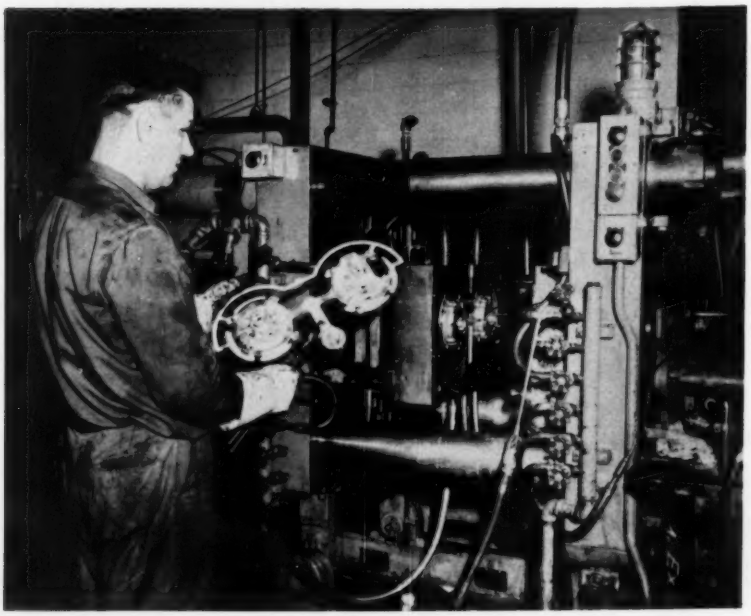


Fig. 15 — Vacuum ladling.

MICROSCOPIC TEST COUPONS

Report of Ductile Iron Research Committee, 12-K

ABSTRACT

A study was made of methods for studying ductile iron graphite structure. On the basis of the study, it was concluded that microscopic examination of a separately cast test coupon was the most economical and rapidly applied single test. A test coupon was designed and found to be satisfactory for the purpose of this test.

INTRODUCTION

After considering a number of possible projects, the AFS Ductile Iron Research Committee* decided that a rapid, positive method of determining whether or not a particular magnesium inoculated ladle of iron produced satisfactory ductile iron castings was needed and should be investigated.

It was reasoned that if the graphite structure was found to be satisfactory, the particular desired mechanical properties could be controlled to a large extent by the cooling rate or subsequent heat treatment, because final mechanical properties of ductile iron are dependent upon the matrix structure. If the graphite structures were substandard, subsequent heat treat could not overcome the reduction in mechanical properties.

A study was made of the methods currently in use, as well as possible new methods. On the basis of these studies, it was concluded that the microscopic examination of a separately cast test coupon afforded the most economical and rapidly applied single test. A number of experienced ductile iron producers have been successfully using this basic plan for various periods of time.

TEST SAMPLE DESIGN

A test sample was then designed, a core box built and samples investigated by members of the Committee and other producers. The results obtained from these tests indicated that for the intended purpose, namely to indicate graphite form, the test casting shown in the figure was satisfactory. In selecting this particular casting it was kept in mind that the sample should be

1) easy to transport so it can be used throughout the average shop.
2) economical to produce.
3) cool reasonably fast, yet slow enough to avoid massive carbides in the micro coupon.

While in a large number of observed cases the matrix structure of the test lug compared favorably with the casting, it is fully realized that this will not always be the case. This condition will exist only when the cooling rates are similar and the shakeout temperature is below the critical range.

The sample is designed with two micro coupons, so that one can be used for immediate examination, while the other may be furnished to a customer or used to evaluate the heat treatment of the castings if they receive a subsequent heat treatment.

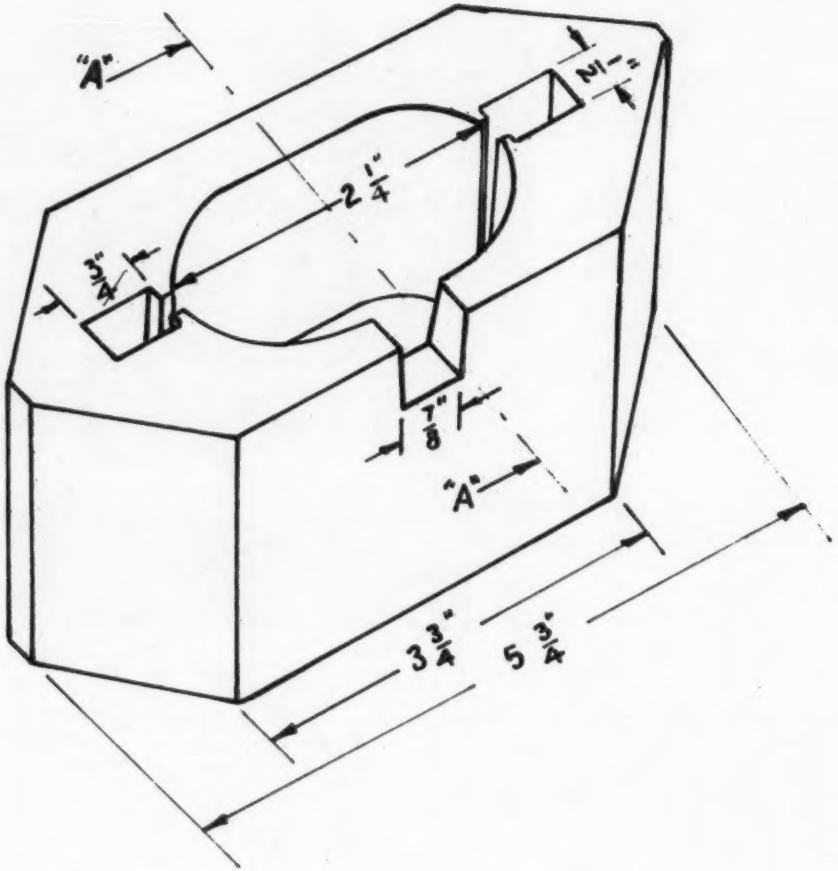
TEST SAMPLE CENTER SECTION

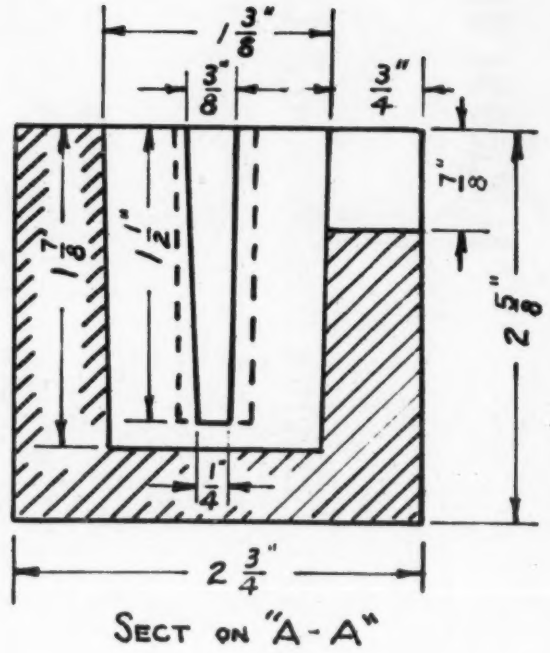
The center section of the test sample is sufficiently large to allow an identification number or letter to be scratched into the core and also to be used for chemical analysis other than carbon. It is recommended that only chilled samples be used for carbon determination. The test samples may be poured from the last portion of the ladle to assure the maximum degree of inspection.

The micro coupons are approximately 1 x ¾ x ½-in. thick, the polishing surface being 1 in. by about ⅜-in. thick. The reduction in thickness results from the breaking notch. The micro sample is of a size that can be quickly polished. In most cases the sample is rough ground on a standard grinding wheel and then finished on a fine grinding wheel using four different silicon carbide abrasive papers—the final paper being 600 grit. This technique has proved satisfactory in the majority of cases where only rapid classification is desired.

(Schematic drawing of test coupon on next page.)

*Harold W. Ruf, *Chairman;* David Matter, *Secretary;* A. W. Anderson; D. M. Marsh; A. H. Rauch; Warren M. Spear; D. L. Crews and H. G. Haines.





Recommended test coupon for microscopic examination of ductile iron.

Knight LETTER

ONE OF A SERIES

To: Foundry Management

Subject: Foundry Automation

"Why should we use the Knight organization to help us develop and carry out a foundry automation program?" is a question I am often asked.

There are, we think, a number of important reasons to use a qualified, "outside" engineering organization for this important planning. The Knight organization, for example:

1. Designed the first fully automated molding unit in 1949-50, producing up to 300 molds per hour with 5½ men producing what 53 did by the old mechanized method. Even today's new units do not exceed the performance of this equipment.
2. Developed the use of the segmented pattern which makes it practical to apply high production techniques to jobbing production problems.
3. Has designed many other "firsts" in the automated and semi-automated production units for bathtubs, sinks, soil pipe, fittings, automotive, electrical and other kinds and types of castings using flasks in sizes up to 4′ x 10′ x 4′.
4. Has key men who have visited more than 2,000 foundries in the United States and Canada, and 800 in Europe.
5. Becomes a part of your organization, temporarily, to bring highly specialized knowledge and training to develop the manufacturing approach best suited to your requirements, to achieve maximum utilization of manpower and equipment with most modern "rigging," and materials which insure maximum productivity, minimum investment, low operating costs and maximum profitability in highly competitive markets.
6. Insures the best working conditions, with buildings, equipment and services requiring minimum maintenance.
7. Provides an overall, long-range plan which may be achieved step-by-step, as conditions and finances warrant without duplication of expense.

Lester B. Knight

KNIGHT SERVICES INCLUDE:

Foundry Engineering • Architectural Engineering • Construction Management • Modernization • Mechanization • Automation • Survey of Facilities • Materials Handling • Methods Industrial Engineering • Wage Incentives • Cost Control • Standard Costs • Flexible Budgeting Production Control • Organization • Marketing

EVIDENCE OF EXPERIENCE

Lester B. Knight & Associates, Inc.

Management, Industrial and Plant Engineers

Member of the Association of Consulting Management Engineers, Inc.

549 W. Randolph St., Chicago 6, Ill.

New York Office—Lester B. Knight & Associates, Inc., Management Consultants, 500 Fifth Ave., New York 36
20111 James Couzens Highway, Detroit 35, Michigan
Knight Engineering Establishment (Vaduz), Zurich Branch, Dreikönigstrasse 21, Zurich, Switzerland
Lester B. Knight & Associates, G.M.B.H., Berliner Allee 47, Düsseldorf, Germany

SHELL CORES made with a Durez foundry resin now save time on half the tonnage formerly poured using green sand cores at The Kuhns Brothers Company, Dayton, Ohio. New jobs go into shell. As core boxes need replacing they are replaced by shell. Just one sand-resin mix, the outcome of intensive testing, covers every shell-core job in the foundry.

How's this for an easy way to handle big cores?

They're hollow inside. That's why they're *one-half to two-thirds lighter to lift* than solid sand cores.

You don't have to bake them like cakes in an oven. And there's no way they can get knocked out of shape before they're done.

You cure them hard right in the core box. They don't warp because they heat up evenly over the entire core surface. They come out ready for setting and pouring.

That isn't all. You can get *more accurate castings* with these shell cores—castings with 5 or 10% less dead weight that has to be machined away.

Translate that saving into pieces per ton of metal poured—and you'll see why so many foundries are interested in cores bonded with Durez resin. Yes—more profitable castings.

25% faster machining At the foundry you see here, they're tapping shell-cored pipe fittings *25% faster than ever before*—thanks to the higher feeds and tool speeds possible with the close finishing tolerances they can hold now.

Foundrymen all over the country get solid dollars-and-cents results like these with Durez foundry resins in shell cores.

They're using the experience of foundry-trained Durez technical men to make the switchover to shell cores as swift and painless as it can be.

They're keeping results *consistent* with the drum-to-drum, month-to-month sameness of Durez resin that makes it possible to set up standard procedures—and stick to them.

How about you? For competent help in shell cores and shell molding, call in your Durez man now.

DUREZ PLASTICS DIVISION

8911 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle No. 142, Pages 143-144

65th CASTINGS CONGRESS

AFS CONVENTION NEWS

SAN FRANCISCO, MAY 8-12, 1961

SUPPLIES & EQUIPMENT EXPOSITION

Society Leads Drive to Cut Exhibit Costs Through New Operating Code

An unprecedented program for stimulating and improving trade and industrial shows, and materially reducing exhibit costs has been initiated by the American Foundrymen's Society. The plan is a detailed operating code for convention servicing companies, convention bureaus, convention halls, and exhibitors.

The code will be initiated at the 1961 AFS Exposition, an operating show to be held May 8-12 in San Francisco.

The plan is intended to correct the main causes of excessive exhibit costs such as excessive mark-ups on service labor rates, abuse of time-and-material provisions, lack of work standards, unnecessary overtime, failure of exhibitors to provide adequate advance data, and failure of officials to act promptly on behalf of exhibitors when special conditions arise.

AFS A Pace-Setter

AFS has set the pace in this important step. Under the leadership of General Manager Wm. W. Maloney, AFS has taken the initiative in drawing up basic policies and detailed "ground rules" to govern all future exhibitions.

Says Maloney, "Unless the constantly growing costs of exhibiting can be brought under reasonable control, those who sponsor or service industrial expositions can expect fewer quality operating and dramatic exhibits, the backbone and main function of an industrial exposition. These operating exhibits are precisely what AFS members want to see. Fewer operating exhibits would decrease the educational benefits of the show and reduce its effectiveness.

"The American industrial exposition is in large degree responsible for the superiority of American efficiency and productivity. Hundreds of thousands of new and improved materials, methods, processes and mechanical devices have been introduced at such expositions, encouraging the acquisition of billions of dollars of capital investments and stimulating adoption of countless labor-saving, cost-saving, and safe-practice methods."

Restoration and maintenance of reasonable exhibit costs can be obtained by fulfilling three fundamental points. These are:

1 Acceptance of full responsibility by all parties concerned to create and maintain a favorable atmosphere of conditions, costs, and fair dealing for industrial conventions and expositions.

2 Establishment and acceptance of primary obligations by those who sponsor and service the industrial convention and exposition.

3 Development of a system for daily control and adjustment of all exhibit service charges.

The acceptance of these conditions by service contractors for the 1961 AFS Exposition is expected to increase the number of operating exhibits at the San Francisco Exposition.

AFS Exhibit Manager Dick Hewitt emphasizes that this is not an Engineered Castings Show but an industry-wide display of the latest in machinery, equipment, and services.

Hewitt urges exhibitors to provide advance data on their actual requirements, essential to minimizing costs. He points out that this is one area where costs rise rapidly when service contractors are forced to meet last-minute exhibitor demands which usually result in high installation costs due to overtime labor.

Congress Features Latest in Research

Top technical papers from the United States and abroad will be presented at the 65th Castings Congress. These will represent the latest investigations in all phases of the foundry field. Most will be from research in this country.

Many papers prepared for the 1961 Convention are being received at AFS Headquarters in Des Plaines, Ill. These are forwarded to the program and papers committees for evaluation and approval.

Among those received are three from research institutions, emphasizing the importance of basic investigations.

Caine Will Discuss Design Importance

J. B. Caine, foundry consultant, Cincinnati, will be the Hoyt Memorial Lecturer at the 65th AFS Congress to be held May 8-12 in San Francisco.

The talk, tentatively titled "Cast Metals and Cast Shapes" will deal with the significance of casting design to the competitive position of the foundry industry.

Caine received the AFS Whiting Gold Medal in 1955 for "Outstanding contributions to the Society and the industry, particularly in the field of foundry research applications." He is one of the best known speakers in the industry and has been active for many years in technical activities. Currently he is serving on committees in the Gray Iron, Sand, and Steel Divisions.

The speaker's background includes service as a pattern clerk, melter, foundry foreman, production manager, chemist, metallurgist, and director of research.

Foundry Industry Spends Heavily

AFS General Manager Wm. W. Maloney states that $509 million will be spent by the foundry industry in the next two years for capital equipment. During the same period an estimated $6.8 billion will go for materials, supplies, and services.

NEWS and VIEWS

Report on European Observations
AFS Committees Plan Programs
Stress Purchasing Fundamentals

A U.S. First: Direct Reduction Makes Molten Metal Cheaper, Faster

Direct reduction took another giant step toward practical realization with the recent unveiling of the Dwight-Lloyd McWane Process by McDowell Co. in Cleveland. The foundry industry is indebted to the McWane Cast Iron Pipe Co. for its tireless efforts in pioneering this break-through development. The D-LM process of ironmaking shortens, speeds, and reduces the cost of producing molten iron and steel for castings. Inexpensive raw materials—iron ore, limestone, and coal fines are mixed, pelletized, sintered, and melted in a cycle that occupies only 50 minutes, eliminates need for blast furnace, and provides molten metal suited for modification to metal-casting.

"Based on experiences at our Cleveland pilot plant," says Robert C. McDowell, president, "A D-LM plant producing about 500 tons of pig iron per day will cost from $6,000,000 to $7,000,000 to build—a capital cost between $35 and $45 per ton. Compare this with a modern blast furnace and coke plant costing about $90 per ton of annual capacity."

Production costs depend on delivered costs of iron ore, coal, and limestone plus local electric power rates. Pilot plant studies indicate that D-LM iron can be produced for about $47 per ton in the Lake Erie region and $39 in St. Lawrence River area where power is only approximately 4 mils per kilowatt hour. These figures include all costs of raw material, labor, maintenance, sales, and distribution. The D-LM furnace consumes between 800 and 900 kwh for each ton of iron produced.

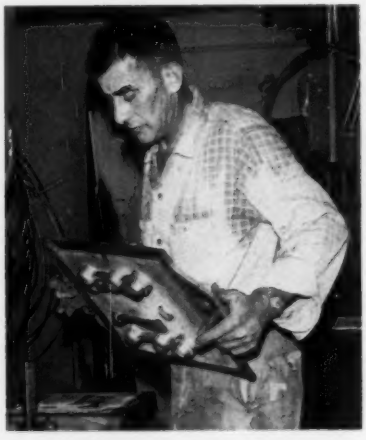
Illustration on Page 124 shows mechanized Cleveland pilot plant. Iron ore and coal are stored in overhead bins at "A"; limestone and other additives at "B." Scale feeders automatically deliver the raw materials onto a belt conveyor (C) at rates adjusted to give the proper metallurgical mix—60% ore, 30% coal, 10% limestone.

This mix drops down into a ball mill (D) where it is wet ground. The discharge is pumped to a vacuum filter (E) which removes water and deposits filter cake into a surge bin (F). A pug mill and table feeder (G) at bottom of bin granulates the cake and drops it onto an inclined belt conveyor (H). The moist mix is thrown onto a "flying saucer"—a rotary steel dish (I) which agglomerates the granular mix into egg-shaped pellets.

Pellets discharge onto a grate leading into a Dwight-Lloyd sintering machine (J). In about 10 minutes the pellets are dried, calcined and pre-reduced. (About 50 per cent of the oxygen in the Fe_2O_3 ore is removed by reaction with the carbon in the coal fines.) The hot pellets (1500-1700 F.) fall into a skip hoist which dumps into a surge

Circle No. 171, Pages 143-144

Don Dalton, Thiem Products, Inc., Milwaukee, operates sand rammer at working meeting of committee 8-R.



Lawrence Winnings, Wagner Castings Co., Decatur, Ill., draws-off matchplate in committee study of pinhole problems.

Malleable Group Studies Pinholes

Test bars and castings were made at a recent working session of the Materials Used in Malleable Foundries Committee of the Sand Division. The committee met at the Magnet Cove Barium Corp. foundry, Arlington Heights, Ill.

Three, 210 pound heats were melted under nitrogen, carbon monoxide, and carbon dioxide atmospheres. The metal was raised to about 2900 F. and cooled to 2750 F. before pouring.

Two molds were made from southern bentonite, western bentonite, and illite-bonded sands. A test bar was also poured from each heat. Castings and test bars will be cleaned and annealed by Wagner Casting Co. Physical and chemical checks will be made.

It was agreed to send the pinhole test plate used in tests to various foundries. Each foundry will duplicate the tests using different clays and their own production sand. These results will be used with the laboratory tests in a final evaluation.

Introducing

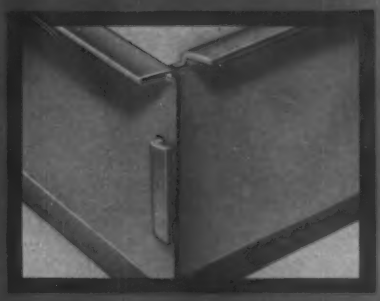
Ster-LINKED® POURING JACKETS

EASIER TO HANDLE

Patent Applied For

- Exclusive chain-link, locked-corner construction facilitates rapid assembly and disassembly
- Corners automatically adjust to any mold angle between 3° and 5°
- Entire steel jacket assembly locks at *one* corner with but *one* cotter
- Tapered, self-positioning lower flanges eliminate possibility of sand cut-ins
- Broad upper reinforcing flanges act as convenient lifting handles
- Knock-down construction minimizes shipping costs and conserves storage space
- Minimum assortment of side-and-end lengths can produce a variety of assembled jacket sizes
- Complete range of sides and ends, in various depths, available from stock

Three corners of every Ster-LINKED pouring jacket have quick-connect joints which operate on conveyor chain-link principle — rectangular mortises through which radiused tenons lock in all but one angular position. Thus each corner holds its side-and-end members securely during all handling, assembly, or disassembly operations — until it is deliberately unlocked by opening the joint to the position where the tenon can be withdrawn from the mortise.



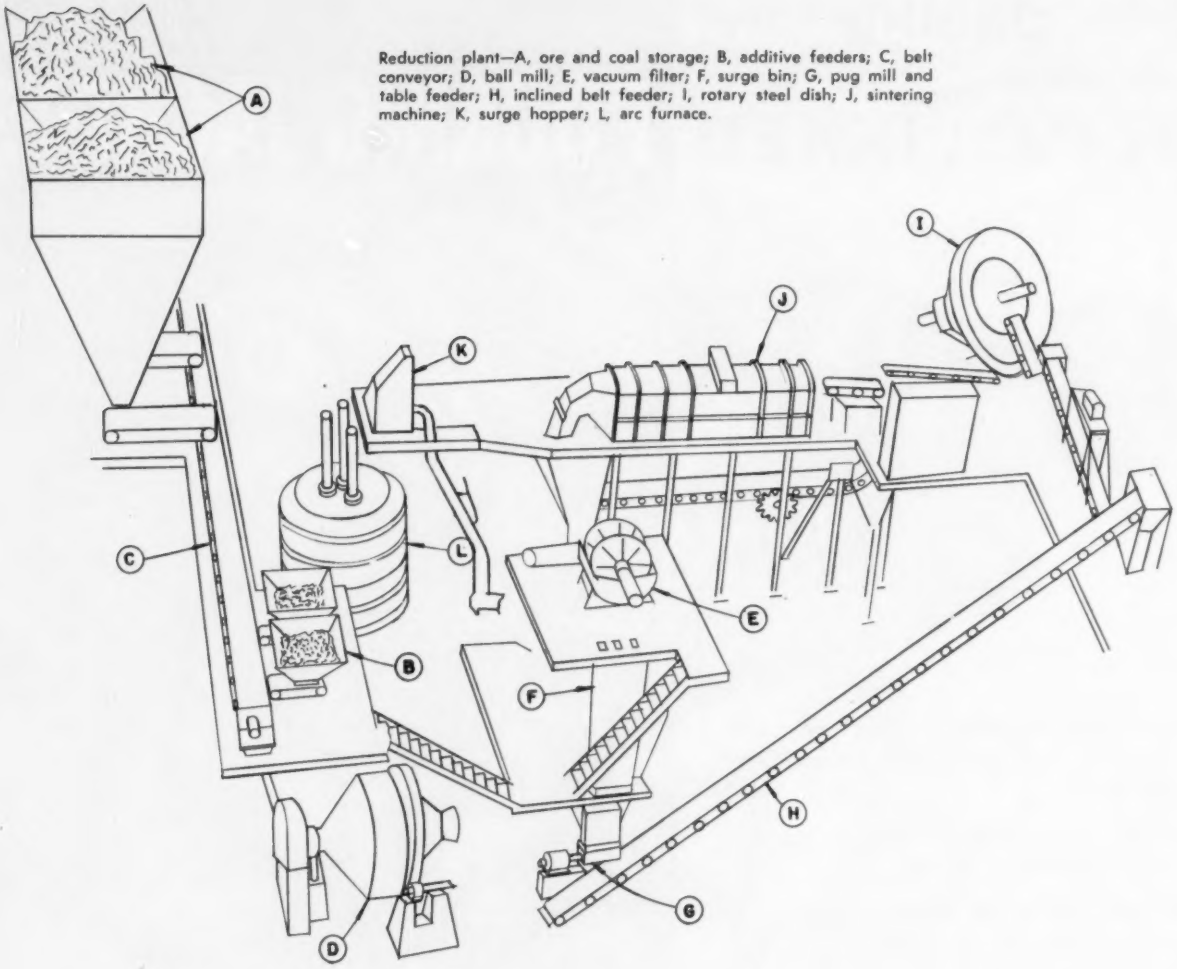
With but one locking corner, Ster-LINKED pouring jackets are far easier to handle—maintain their assembled shape even when the locking corner is open. No members become disengaged during filling or removal from the mold. No multiple locks are employed to make handling awkward. Lock is simple, yet positive. Single cotter holds straight tenon securely in locking-corner mortise — is easily replaced by any handy pin if misplaced or damaged.

AD-4844

Sterling WORLD WIDE SERVICE

STERLING NATIONAL INDUSTRIES, Inc.
Founded 1904 as Sterling Wheelbarrow Co.
Milwaukee 14, Wisconsin, U. S. A.

Associate: STERLING FOUNDRY SPECIALTIES LTD.
LONDON • BEDFORD • JARROW-on-TYNE, England



Reduction plant—A, ore and coal storage; B, additive feeders; C, belt conveyor; D, ball mill; E, vacuum filter; F, surge bin; G, pug mill and table feeder; H, inclined belt feeder; I, rotary steel dish; J, sintering machine; K, surge hopper; L, arc furnace.

hopper (K). Sintered pellets feed through the roof of a three-electrode arc furnace (L). Electrodes are held above the molten metal and are completely surrounded by the charge burden. In a matter of minutes the pellets melt into the bath.

The limestone forms a basic slag with the silicious gangue content of the sintered ore. About 800 pounds of slag are formed per ton of molten iron. The remaining oxygen and carbon in the pellets react to form CO which is burned off in flare stacks. Every two hours molten iron and slag are tapped at 2800 F.

Since mixing, sintering, and charging are done on a continuous basis, continuing tapping could be designed into the installation if desired. Metal analysis is around 3.5 per cent carbon, 2.25 per cent silicon, 0.03 per cent sulfur. Manganese as well as other alloys can be added by blending ores containing the desired elements into the original mix.

To make steel, the molten metal would probably have to be transferred to another furnace for oxygen blowing or dilution with low carbon scrap.

The pilot plant is operating at the rate of 12 tons per 24 hours. For the process to be competitive it's estimated that a commercial installation should produce in excess of 100 tons per day. McWane Pipe Co. is considering construction of a plant with a 500 ton capacity to meet requirements of their pipe foundry. Thomas E. Ban, vice-president-research for McDowell, explained that "Several foundries in one area could work together and build a direct reduction plant with sufficient output to satisfy their combined needs." Although the process is most efficient when operated on a continuous basis it can be run intermittently. Another alternative would be to pig the metal when not needed. This pig iron could be stockpiled for later use or sold to local foundries.

Read the article on page 38 of this issue which describes a new Belgian process for direct reduction of iron ore.

T&RI Changes Date of Nov. Course

To prevent conflict with the national election, the AFS-T&RI course, "Metallurgy of Light and Copper-Base Alloys," originally scheduled for Nov. 7-9 in Chicago has been rescheduled for Nov. 9-11.

The remaining T&RI course for 1960, "Sand Control and Technology," will be held as scheduled, Dec. 5-7 at Detroit.

Observe European Foundry Practice

European research, production methods, and emphasis on quality impressed U.S. foundrymen on tour following the International Foundry Congress held recently in Zurich, Switzerland.

In a special report to MODERN CASTINGS, G. P. Antonic, Motor Castings Co., Milwaukee, stated that foundries showed two extremes: within the same foundry, areas are either fully mechanized to an extent far greater than their American counterpart; or, large areas exist where there are no cranes, molding machines, or compressed air. Molds were hand rammed and walked off.

Henry Zimnawoda, National Engineering Co., Chicago, states that large foundries in Switzerland were mechanized in a rather luxurious way, but very impressive. In medium-sized plants, many home-made, very practical devices, proved high engineering standards of the management.

Both observers told of the American influence. Zimnawoda observed it in foundry layouts. Antonic noticed it in American machines and production techniques. He stated that in Europe there is a greater emphasis on theoretical and basic research while in the United States the emphasis is on production and equipment.

In commenting on European production, Zimnawoda said, "Because of the highly exaggerated requirements of European casting users, and a big variety of short series of jobs, the production tempo is much slower than in the U.S. The appearance of the finished castings on the average is better. In general, all plants are remarkably clean, production methods smooth, with the operator's efforts concentrated on exact work rather than on speed."

He noted that the tremendous amount of cheap electrical power in Austria and Switzerland has resulted in a much greater use of electric heat treat ovens and furnaces than are used in the United States for the same purpose.

Antonic was surprised to see so little of the shell and CO_2 processes, stating: "American foundrymen had been led to believe . . . . that European foundries had converted their core facilities to these new methods almost exclusively.

"It appears that foundry problems are not unique to any particular country, nor are they minimized in those countries that have large, and apparently effective apprentice programs."

T&RI Purchasing Course Stresses Fundamentals

To obtain true charges, costs of foundry materials must be figured to the point of consumption. Too often purchasing agents are concerned only with the invoice price and shipping charges.

These points were constantly emphasized at the three-day AFS Training & Research Institute course on economical purchasing of foundry materials.

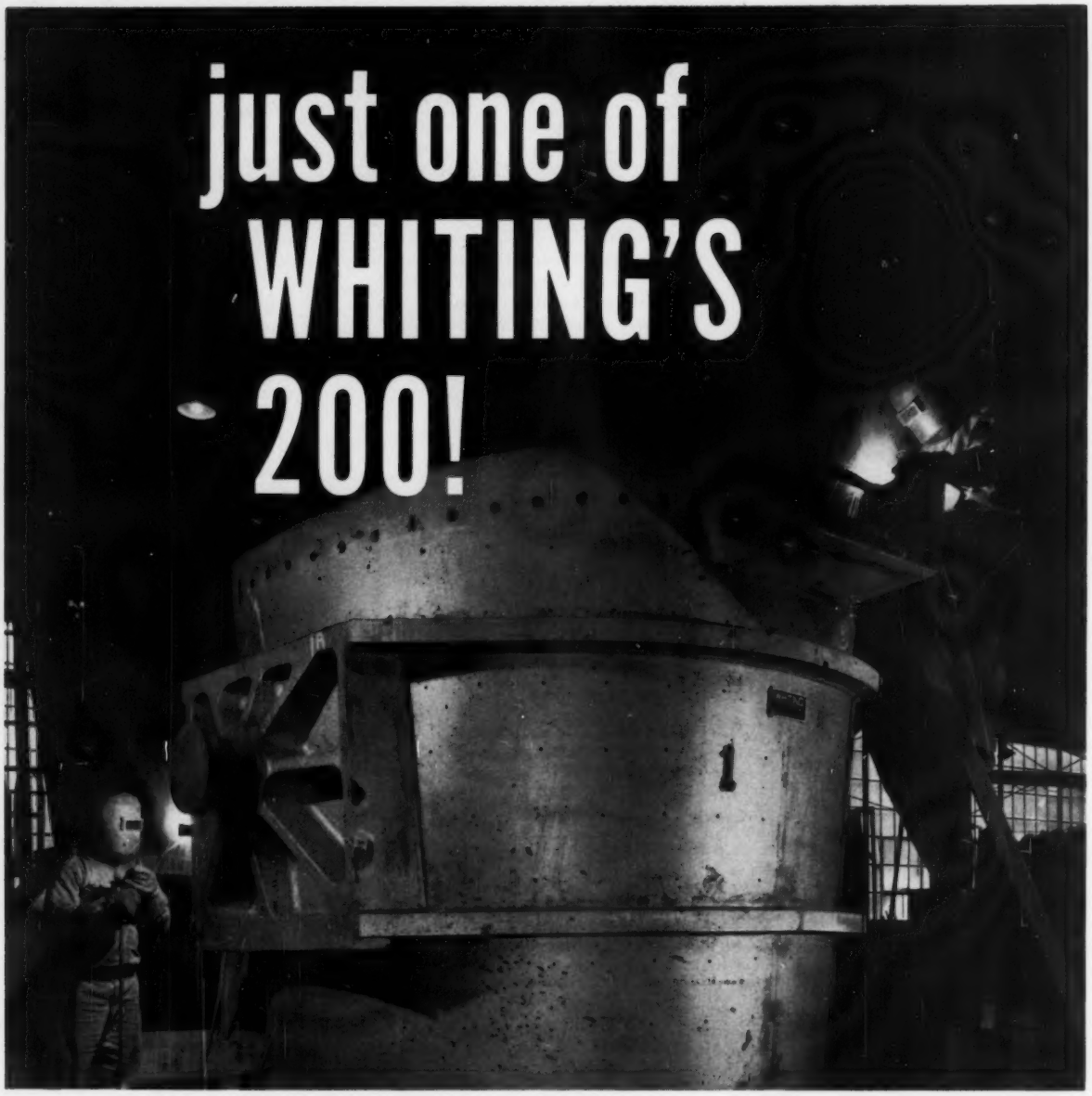
The opening day was devoted to the basic philosophy and function of purchasing agents and purchasing departments as related to the overall operations of a foundry. Second and third days were concerned with peculiarities and details of buying specific foundry materials and equipment and considered in view of direction relationship of profits.

Instructors were: Robert E. Schmidt, Hills-McCanna Co., Chicago; S. C. Massari, AFS Technical Director; M. L. Lohnes, Caterpillar Tractor Co., Peoria, Ill.; W. H. Day, Shell Oil Co., Chicago; Donald E. Dice, Albion Malleable Iron Co. R. E. Betterley, AFS Training & Research Institute Training Supervisor who conducted the course evaluation.

Sand Division Fineness and Distribution Committee conducted its meeting at AFS Headquarters in Des Plaines, Ill.

Steel Division Research Committee Chairman, J. A. Rassenfoss, American Steel Foundries, Chicago, presides at meeting conducted in Chicago.

Sand Division Basic Concepts Committee at its Chicago meeting discussed bonding clays, correlation between the angularity factor and photomicrographs and other subjects.



This 60-ton steel mill ladle is just one of more than 200 types and sizes designed by Whiting engineers! Built to A.I.S.E. specs, it features cast steel trunnion bases, forged steel trunnions, and adjustable swivel-type bottom tapping lever for easy control and long service life with low maintenance. Whatever *your* ladle requirements—in capacities from 100 lbs. to 200 tons— Whiting has a profitable answer for you.

FREE CATALOG! . . . Yours on request to: Whiting Corporation, 15628 Lathrop Avenue, Harvey, Illinois

90 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

WHITING

FOUNDRY EQUIPMENT

MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES;® FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

Circle No. 146, Pages 143-144

CHAPTER NEWS

Texas Chapter

Successful Panel Programs

Highly successful chapter meetings have been conducted by the Texas Chapter through panel discussions. At the opening meeting, the chapter dealt with the mental processes involved in gating and risering problems.

Foundrymen were guided by panel members and an AFS film, "Horizontal Gating," was shown to demonstrate how metal flows in a mold. Members were then divided into teams. Team A studied a 1500-pound casting; team B, a 10-inch pressure valve.

It was agreed that the first consideration was casting specifications as well as what was expected of the casting. Each design poses a special problem. It may be metal sections, hot spots, or riser locations.

Information sources include research data, standard data, and past experience with similar castings.

Panel members emphasized that the casting must be broken down into component parts for study and measured against standard information. Compromise is essential in designing but certain basic factors must be kept in mind.

Panelists covered such subjects as, normal yield, riser calculating, feeding range, use of chills, cores, feeding pads, bosses, pattern accuracy, flanges, and gate locations.

J. R. Hewitt, Quality Steel Casting Co., Houston, served as moderator. Members were Ross Williams, East Texas Steel Casting Co., Longview; R. E. Grimes, Federal Steel Products Corp., Houston; L. C. Hollien, Texas Electric Steel Casting Co., Houston; and L. C. Hommel, Quality Electric Steel Casting Co.

The program has several advantages including a high degree of participation by members, an informal atmosphere, availability of expert opinion, and the study of a practical foundry problem.

Program chairmen of other chapters are urged to consider the use of a panel program in future plans. Considerable success with similar meetings is reported by other chapters.

British Columbia Chapter

Foundry Noise Problems

Dangers faced by foundries in the area of noise were discussed by H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control. He listed many of the common problems and their cures.—by J. G. Smith

Coke production was observed by members of the Connecticut and New England Chapters at the Connecticut Coke Co., New Haven, Conn. Left to right: Connecticut Chapter Chairman Larry J. Litalien, Vice-Chairman Stafford W. Chappell, New England Chapter Vice-Chairman Lewis W. Greenslade, Jr., Thomas E. Thibeau, Connecticut general manager, Edward L. Flahive, Connecticut Coke general sales manager, and C. Russell Walton, vice-president, Eastern Gas & Fuel Associates.—by J. H. Orrok

TEXAS—Gating and risering problems discussed at a recent meeting with actual problems involved. Conducting the study was a panel composed of Ross Williams, East Texas Steel Casting Co., R. E. Grimes, Federal Steel Products Corp., R. J. Hewitt, Quality Electric Steel Castings Co., L. C. Hommel, Quality Electric Steel Casting Co., and L. C. Hollien, Texas Electric Steel Casting Co.—E. Eugene Silver

WESTERN MICHIGAN—Plans for the coming chapter year are discussed by Treasurer Charles Pierce, Western Michigan Steel Foundry Co.; Chairman Walter Blackmer, Muskegon Piston Ring Co., and Secretary, Charles Cousineau, Carpenter Bros., Inc. —by J. L. Brooks

NORTHEASTERN OHIO—Making of scrap was discussed by a local panel. Participants were George P. Krumlauf, Republic Steel Corp.; Alexander Barczak, Superior Foundry, Inc.; Victor J. Obrig, Sterling Foundry Co.; and Walter H. Siebert, Cleveland Standard Pattern Works. —by Harold Wheeler

SOUTHERN TIER SECTION—Central New York Chapter, heard Clyde A. Sanders, American Colloid Co., Skokie, Ill., discuss various casting processes. He placed special emphasis on the ultimate mechanization obtainable, especially with green sand molding.

Sanders also pointed out the technological progress in Europe and the emphasis on research. Shown are Chapter Chairman I. Niles, speaker Sanders, Vice-Chairman W. G. Parker, and Director Louis Wallitt.—by Wally Korona and F. H. Troy

Two hundred New England area foundrymen attended the Connecticut Coke Co., New Haven, Conn., on a plant visitation tour and were treated to a shore dinner.

CENTRAL ILLINOIS—Chapter members serving on the Controlled Castings Quality Committee met recently at Brass Foundry Co., Peoria. The committee is assisting with acquisition of pictures of defects for the new AFS ANALYSIS OF CASTINGS DEFECTS HANDBOOK. Foundries in the area are requested to contact committee members.

Shown are G. F. Lloyd, Brass Foundry Co., D. P. Schmidt, International Harvester Co., Canton Works; Committee Chairman William Thornton, Brass Foundry Co.; R. E. Beebe, International Harvester Co.; and Wally Walz, Caterpillar Tractor Co.—by Charles W. Search

NORTHEASTERN OHIO—What a foundry can expect with a plastic core binder was discussed by Roy J. Handwerk, B. F. Goodrich Chemical Co., center. On left is Chapter Chairman N. J. Stickney, Sand Products Corp. On right, Richard Hanson, Solon Foundry, Inc., technical chairman.

Northeastern Ohio Chapter

Opens Technical Season

Simultaneous pattern, ferrous, and non-ferrous meetings opened the chapter's technical year.

Patternmakers heard James Byrne and Russell G. Fox, certified public accountants, Arthur Andersen & Co., discuss "What Costs We Should Recover." Byrne stated that although all costs should be recovered, only direct costs such as materials and labor are usually recovered. Indirect costs such as equipment depreciation receive too little consideration. Equipment depreciation is written off over a period of years by means of equal amounts based on the purchase price but inflation is not taken into account. According to Byrne, each depreciation installment must be adjusted by an inflation factor to get a value in terms of current dollars rather than in terms of purchase-price dollars.

Fox pointed out that because this method of calculating costs is not yet recognized by the government, standard financial statements must be prepared for tax purposes. However, he suggested incremental costs of inflation be accounted for by this method on stockholders' statements. Such a method will tend to lower "profits" but will give the most realistic evaluation of costs.

At the ferrous section, a panel discussed "How to Make Scrap." Walter H. Siebert, Cleveland Standard Pattern Works, explained what factors in the design and construction of patterns can lead to defective castings. Alexander D. Barczak, Superior Foundry, Inc., cited the relationship between various types of defects and such foundry operations as gating and risering, sand properties, and molding practice. George P. Krumlauf, Republic Steel Corp., discussed defects from the standpoint of metal composition and melting pouring practices. An analysis of 31 different types of defects indicates that the principal operations responsible for them are pouring and molding practice, followed by gating and risering, molding sand practices, and coremaking practice.

Non-ferrous foundrymen were addressed by Roy J. Handwerk, B. F. Goodrich Chemical Co., who spoke on "What a Foundry Can Expect with a Plastic Core Binder." Handwerk stressed that the real competition for foundries is the fabrication of parts non-casting methods. Lack of consistent quality in castings has led many component buyers to pay more for parts by other processes so that they can be assured of consistency.

Foundries can achieve more con-

sistent products, and plastic core binders—particularly of the acrylic type—are one tool they can use. Acrylic binders are said to evolve very little gas, produce fine surface finish, achieve close tolerances, and collapse easily on shakeout. In addition, mixing is relatively simple.—by William G. Gude, Jack C. Miske, and Wallace D. Huskonen

Cincinnati Chapter

Holds Simultaneous Sessions

Sand facts that lower costs were explained by Joseph Schumacher and Edward King of Hill & Griffith Co.

King spoke to the ferrous group, basing his presentation on the use of mold hardness as a quality control factor for both casting finish and dimension. A number of sands were illustrated, showing green and dry properties when rammed at various levels of mold hardness. Forms of scrap, surface defects and dirt inclusions were attributed to low levels of mold hardness and non-uniform ramming. It was brought out that current foundry practice is tending toward intermediate levels of clay bond content to give sands which had good response to molding, developed adequate mold hardness. They are much easier to control and maintain, as compared to sands of lower clay content. In conclusion, King gave a short presentation of the mechanics involved in mulling and mixing materials, the effect of temperature on sand during mulling, and simplified methods of controlling clay content.

Schumacher spoke on non-ferrous synthetic sand practice. He covered typical sand formulations and the necessity of building the synthetic practice from the core room, so that the burned core sand would become the base for the molding sand used to give excellent finished castings made to close dimensional tolerances.

Of particular interest was a series of slides showing how casting dimension is actually changed by moisture variations in the same base molding sands. Consideration of gating practices as related to natural versus synthetic sands and simplifed methods of sand control were included.—by J. L. Shinn

Western Michigan Chapter

Holds Annual Picnic

Fall activities were started with the 20th annual picnic held in Muskegon, Mich. Six hundred foundrymen and their friends attended. —by J. R. McNamara

CHESAPEAKE—Alan Wood Steel Co., Conshohocken, Pa., hosted members of the chapter. Following the dinner and tour, George G. Karian, spoke on iron powder applications and discussed the use of iron powder melting stock in foundries for specialty applications. Vice-President Howard W. Read welcomed foundrymen and Marshall J. Evans and Thomas D. Owens conducted the tour.—by Allen H. Fox

CENTRAL INDIANA — More than 450 foundrymen attended the annual picnic. Left to right are Chairman Joe Essex, Golden Foundry Co., Columbus, Indiana, E. H. King, Hill & Griffith Co., Cincinnati, and former Chapter Chairman T. E. Smith, Central Foundry Div., GMC, Danville, Ill.—by William R. Patrick

NORTHEASTERN OHIO—Patternmakers heard James Byrne and Russell G. Fox, Arthur Andersen & Co., discuss cost problems. Frank J. Oklessen, center, Motor Patterns Co., was technical chairman.

SOUTHERN CALIFORNIA—One of the largest turnouts in recent years attended the 23d annual summer outing. The outing was held at the Lakewood Country Club.

WASHINGTON—Causes and remedies of foundry ventilation problems were outlined by H. J. Weber, AFS Director of Safety, Hygiene, and Air Pollution Control program. Examples were shown of incorrect design and installation.

Shown: John E. Langhans, Puget Sound Naval Shipyard, speaker Weber, R. T. Torgerson, Boeing Airplane Co., and AFS Regional Vice-President James Wessel, Puget Sound Naval Shipyard.—by Jim McComb

CENTRAL OHIO—Shown at Board of Directors meeting are John Dustheimer, Keener Sand & Clay Co., Columbus, membership chairman; Jerry Havnen, Burnham Corp., Zanesville, chapter chairman; and Nard Stapf, foundry supplier, treasurer.—by Joseph A. Riley, Jr.

WISCONSIN—E. Reinschmidt, Lawran Foundry Co., left, and Ray Cochran, R. Lavin & Sons, discuss Cochran's talk on non-ferrous melting practices.—by Bob DeBroux

TRI-STATE William Pitts, former Chairman, and Membership Chairman Carl Townsend, both of Oklahoma Steel Castings Co., show last years' membership gain and goal for this year.—by Bobby Bell

CENTRAL NEW YORK—D. L. Colwell, right, Apex Smelting Co., Cleveland, spoke on casting aluminum in sand, permanent molds, and dies. On right is W. D. Dunn, Oberdorfer Foundries, Inc., Syracuse, N. Y.—by Anthony Izzo

ST. LOUIS—Vernon Lich, General Steel Castings Corp., is congratulated for talk on modernization, mechanization, and maintenance by Technical Chairman A. P. Steinhauser, American Steel Foundries.—by W. E. Fecht

CENTRAL OHIO—Clyde Sanders, left, American Colloid Co., Skokie, Ill., discussed the future of the foundry industry at the opening meeting. He emphasized that the answers to better castings lie in part in better and finer sands and improved ramming techniques. On right is Chapter Chairman J. A. Havnen, Burnham Corp.—by Joseph A. Riley, Jr.

TRI-STATE—George DiSylvestro, American Colloid Co., Skokie, Ill., right, and Edward O'Brien, Oklahoma Steel Castings Co., at head table. DiSylvestro spoke on veining and penetration.—by Bobby Bell

Central Michigan Chapter

Provides Scholarship

A $500 annual scholarship in foundry technology has been presented by the chapter to the department of engineering and technology at Western Michigan University, Kalamazoo, Mich.

The scholarship money will be used to provide grants of $125 per semester per student, with recipients to be selected from Barry, Branch, Calhoun, Eaton, Hillsdale, Ingham, Jackson, Kalamazoo, and St. Joseph county high school graduates.

Western Michigan University provides a two-year foundry technology program.

Utah Chapter

Hears H. J. Weber

Loss of hearing due to industrial noises was explained by H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control. He outlined workmen compensation laws as they are related to the loss of hearing.

He explained the effects of different frequencies and the intensities on hearing. Much higher noise levels can be tolerated in the lower frequency than in the higher frequency ranges.

Weber identified several foundry operations having noises which are frequently in excess of the damage-risk criterion. These include shakeout, tumbling mills, peening, and grinding. Means of curbing these noises include isolators, acoustical material, and protective equipment. Personal protective equipment such as ear plugs should be fitted by qualified medical personnel.

Chapter Chairman E. H. Backman, Backman Foundry Co., presided.

Among those attending were plant doctors, safety engineers, and two members from the Utah State Industrial Commission.—by J. M. Bushnell

Controlled Casting Quality Committee of the Sand Division held a two-day meeting in Chicago to plan future activities of the group.

New England Chapter
Connecticut Chapter

Make Tour of Coke Plant

Two hundred foundrymen from the AFS New England and Connecticut Chapters toured the Connecticut Coke Co. plant, New Haven, Conn.

Following the tour, visitors were treated to a shore dinner.

Company guides explained the operation of coke ovens, by-product equipment, material handling, and other auxiliary apparatus.

Hosts were Thomas L. Thibeau, vice-president and general manager, Connecticut Coke Co., Edward L. Flahive, general sales manager, and C. Russell Walton, vice-president, Eastern Gas and Fuel Associates, Boston, of which Connecticut Coke is a subsidiary.

New England officers attending include Vice-President L. J. Greenslade, Jr., Brown & Sharpe Mfg. Co., Providence, R. I.; and Secretary Daniel J. Pendergast, Sterling National Industries, Inc., Waltham, Mass. The Connecticut Chapter was represented by Chairman Larry J. Litalien, Waterbury Div., Textron Corp., Waterbury, Conn., and Vice-Chairman Stafford W. Chappell, Electric Boat Div., General Dynamics Corp., Groton, Conn. —by J. H. Orrok

Detroit Chapter

Challenge of the Sixties

A promising ten year period for those not afraid of competition was predicted by Ed Walsh, Foundry Education Foundation. During this period, he said, there will be a 15 per cent increase in population, 25 per cent increase in living standards, 50 per cent rise in gross national product, and 13 per cent greater working population.

Walsh recomended use of the AFS Training & Research Institute program and chapter meetings to prepare personnel and induce student enigneers into the industry.

Foundries, he said, must offer summer employment to students and let them know that opportunity and personal reward for the foundry engineer is greater than in many industries.

The foundry engineer should bring more of the "know why" than the "know how," to the industry, said Walsh.

Among the guests were 25 college students from Wayne University, University of Detroit, Lawrence Technical Institute, and General Motors Technical Institute. Joseph Metyko, retired, was given a life-time service membership for his 25 consecutive years as a member.—Joseph H. Barron, Jr.

Twin City Chapter

Foundry Plastic Patterns

Correct use of plastics for patterns and core boxes was outlined by Stanley Munson, Ren Plastics. Success of the system is founded on three principles—proper application, material selection, and proper construction.

Complex contoured patterns and duplications may be molded, saving expensive machining costs. Plastic patterns and duplications are sturdy, practically eliminating dents, break-ups and costly repairs. This toughness, accuracy, and longer wearing qualities generally reduces the chances for scrap less. When properly constructed, plastic equipment will give economies through high impact resistance, longer wear, superior surface finishes, greater accuracy, and increased stability.—by Matt Granlund

San Antonio Chapter

Patternmaking Techniques

Patternmaking and plastic tooling and patternmaking with epoxy resins were discussed by Bill Rieser, Glenney Pattern Works.

In addition to the talk and examples of patterns and core boxes, a film was presented on the use of epoxy resins.—by Frank E. Page

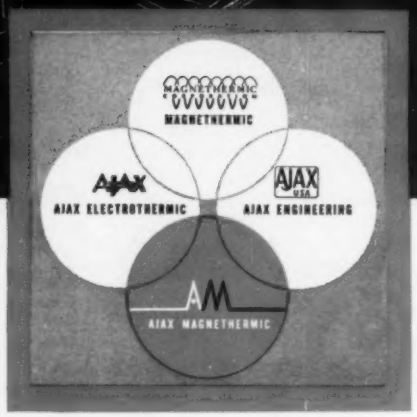
WISCONSIN—W. D. Carleton, Union Carbide Corp., technical chairman, greets speaker R. A. Clark, Union Carbide Metal Corp., Div. Union Carbide Corp. Clark spoke on ferroalloys in the iron foundry.

Wisconsin's opening program featured simultaneous sessions for gray iron, steel, pattern, malleable, and non-ferrous interests.—by Bob DeBroux

ST. LOUIS—Former Chapter Chairman R. E. Hard, St. Louis Coke & Foundry Supply Co., left, gives gavel to new chairman E. E. Hart, Great Lakes Carbon Co.—by W. E. Fecht

MALLEABLE DIVISION RESEARCH committee reviewed current projects and made plans for future activities. Clockwise: E. J. Stockum, W. K. Bock, J. H. Lansing, R. P. Schauss, S. C. Massari, C. F. Joseph, R. W. Heine, Eric Welander, P. F. Ulmer, T. W. Mueller, Carl Loper, W. D. McMillian. A progress report was presented on work at the University of Wisconsin, Madison, Wis., done under sponsorship of the committee.

These twin 1000-lb. melting furnaces prepare copper for metal powder at the St. John's, Michigan, plant of Federal-Mogul-Bower Bearings, Inc.



WATCH AM

FOR THE NEW IDEAS IN HEATING AND MELTING BY INDUCTION

Copper Melting Furnaces, one of many products of AM, for the heating or melting of metals by Induction.

"induction heating is our only business"

Ajax Magnethermic CORPORATION

GENERAL OFFICES
P. O. BOX 639
Youngstown 1, Ohio

TRENTON DIVISION
930 Lower Ferry Road
Trenton 5, New Jersey

YOUNGSTOWN DIVISION
3990 Simon Road
Youngstown 1, Ohio

Circle No. 144, Pages 143-144

AFS Chapter Meetings

NOVEMBER

Birmingham District . . Nov. 18 . . Jefferson Davis Hotel, Anniston, Ala. . . J. S. Schumacher, Hill & Griffith Co., *"Foundry Sands & Their Function."*

British Columbia . . Nov. 18 . . Leon's, Vancouver, B. C.

Canton District . . Nov. 3 . . Timken Roller Bearing Co., Canton, Ohio . . *Plant Visitation.*

Central Illinois . . Nov. 7 . . American Legion Hall, Peoria, Ill. . . R. H. Jacoby, St. Louis Coke & Foundry Supply Co., *"The Young Engineer in Industry."*

Central Indiana . . Nov. 7 . . Athenaeum Turners, Indianapolis . . L. S. Krueger, Pelton Steel Casting Co., *"Quality Control."*

Central Michigan . . Nov. 16 . . Hart Hotel, Battle Creek, Mich.

Central New York . . Nov. 11 . . Drumlins Country Club, Syracuse, N. Y.

Central New York, Southern Tier Section . . Nov. 18 . . Mark Twain Hotel, Elmira, N. Y.

Central Ohio . . Nov. 14 . . Seneca Hotel, Columbus, Ohio . . W. G. Ferrell, *"Future of the Foundry."*

Chesapeake . . *No Meeting.*

Chicago . . Nov. 7 . . Chicago Bar Association, Chicago . . H. W. Dietert, H. W. Dietert Co., *"Reducing Casting Loss."*

Cincinnati District . . Nov. 14 . . Suttmillers Restaurant, Dayton, Ohio.

Connecticut . . Nov. 22 . . Continental Restaurant, Bridgeport, Conn. . . E. J. Texler, The Osborn Mfg. Co., *"Automation—How Far Shall We Go?"; Plant Visitation,* Detroit Controls Div., American Standard Sanitary Corp.

Corn Belt . . Nov. 18 . . H. W. Schwengel, Modern Equipment Co., *"New Developments in Water Cooled Cupolas."*

Detroit . . Nov. 16 . . Prince Edward Hotel, Windsor, Ont. . . *Joint Meeting with Ontario Chapter.*

Eastern Canada . . *No Meeting.*

Eastern New York . . Nov. 15 . . Panetta's Restaurant, Menands, N. Y.

Metropolitan . . Nov. 7 . . Military Park Hotel, Newark, N. J. . . W. H. Ruten, Polytechnic Institute of Brooklyn, *"Quality Castings Through Training" and Film, "Cast Metals and You."*

Mexico . . Nov. 28 . . Ave. Chapultepec 412, Mexico City, Mexico.

Michiana . . Nov. 14 . . Club Normandie, Mishawaka, Ind. . . R. Cochran, R. Lavin & Sons, Inc., and J. R. Lowry, Steel Sales Corp., *"Alloyed Gray Iron Castings."*

Michigan Regional Foundry Conference . . Nov. 3-4 . . Bancroft Hotel, Saginaw, Mich.

Mid-South . . Nov. 11 . . Claridge Hotel, Memphis, Tenn.

Mo-Kan . . Nov. 17 . . Fairfax Airport, Kansas City, Kans. . . H. W. Schwengel, Modern Equipment Co., *"New Developments in Water-Cooled Cupolas."*

New England . . Nov. 9 . . University Club, Boston.

Northeastern Ohio . . Nov. 10 . . Manger Hotel, Cleveland . . *Ferrous Groups*: J. Stana, Warner & Swazey Co., *"Foreman's Place in Management"; Non-Ferrous Group*: R. A. Flinn, Non-Ferrous Founders' Society, *"Copper-Base Alloys"; Pattern Group*: R. H. Sutter, Sutter Products Co., *"Hot Core Box Adaptation & Cores."*

Northern California . . Nov. 14 . . Lake Merritt Hotel, Oakland, Calif.

Northern Illinois & Southern Wisconsin . . Nov. 8 . . Beloit Country Club, Beloit, Wis. . . C. A. Sanders, American Colloid Co., *"Sand."*

Northwestern Pennsylvania . . Nov. 28 . . Amity Inn, Erie, Pa.

Ontario . . Nov. 18 . . Prince Edward Hotel, Windsor, Ont. . . *Joint Meeting with Detroit Chapter.*

Oregon . . Nov. 16 . . Heathman Hotel, Portland, Ore.

Philadelphia . . Nov. 11 . . Engineers' Club, Philadelphia . . G. DiSylvestro, America Colloid Co., *"Veining Tendencies of Cores."*

Piedmont . . Nov. 4 . . Greenville, S. C. . . D. L. LaValle, American Smelting & Refining Co., Federated Metals Div., *"Aluminum Castings Defects & Their Correction."*

Pittsburgh . . Nov. 21 . . Webster Hall Hotel, Pittsburgh, Pa. . . B. W. Niebel, Penn State University, *"Engineering Analysis & Design in the Foundry."*

Quad City . . Nov. 21 . . LeClaire Hotel, Moline, Ill. . . C. C. Sigerfoos, Michigan State University, *"The Japanese Foundry Industry."*

Rochester . . Nov. 1 . . Manger Hotel, Rochester, N. Y. . . A. B. DeRoss, Kaiser Aluminum & Chemical Sales, Inc., *"Aluminum Practices."*

Saginaw Valley . . *See Michigan Regional Foundry Conference.*

St. Louis District . . Nov. 10 . . Edmonds Restaurant, St. Louis . . A. Dorfmueller, Jr., Federal Foundry Supply Div.,

PQ SILICATES
for all needs

PQ's extensive line of soluble silicates (over fifty) offers the products needed for dozens of industrial processes.

A few PQ Silicates which may have special interest to you:

N . . . Ratio $\%Na_2O:\%SiO_2$, 1:3.22, 41° Baume (68°F.), viscosity 1.8 poises.

K . . . Ratio $\%Na_2O:\%SiO_2$, 1:2.90, 47° Baume (68°F.), viscosity 9.6 poises.

RU . . . Ratio $\%Na_2O:\%SiO_2$, 1:2.40, 52° Baume (68°F.), viscosity 21.0 poises.

D . . . Ratio $\%Na_2O:\%SiO_2$, 1:2.0, 50.5° Baume (68°F.), viscosity 3.5 poises.

PQ silicates have been produced for a century. You are welcome to draw on this long experience.

When you need silicate service, see PQ.

PHILADELPHIA QUARTZ COMPANY
1125 Public Ledger Bldg., Philadelphia 6, Pa.

TRADEMARKS REG. U.S. PAT. OFF.

PQ SOLUBLE SILICATES

Associates: *Philadelphia Quartz Co. of California Berkeley & Los Angeles, California; Tacoma, Wash. National Silicates Limited, Toronto & Valleyfield, Canada.*

PQ PLANTS: ANDERSON, IND.; BALTIMORE, MD.; BUFFALO, N.Y.; CHESTER, PA.; JEFFERSONVILLE, IND.; KANSAS CITY, KANSAS; RAHWAY, N.J.; ST. LOUIS, MO.; UTICA, ILL.

Circle No. 145, Pages 143-144

Smart fellow — that Satan! He's found out our Koppers Premium Foundry Coke maintains a higher temperature range and keeps operating costs way down. Naturally he wants to order some.

But we wouldn't sell him. We sell only the *good* guys. We've found that once we have sold them — they *stay sold* and remain good customers of ours forever and ever.

The reasons are quite simple: Koppers Coke is prepared from the very best quality West Virginia coals, skillfully blended and baked the right length of time. It is absolutely uniform in *size, strength, structure* and *chemical analysis.* (We check each day's run to be sure.) And because of its superior physical qualities, its high carbon and low ash, Koppers Coke enables foundrymen to maintain higher temperatures which increases the cleanliness of the iron and helps cut fuel consumption.

Just for the devil of it, why don't you make your next order Koppers Premium Foundry Coke? It's available anywhere in the U. S. or Canada in sizes to fit your needs. Koppers Company, Inc., Pittsburgh, Pennsylvania.

Koppers Premium Foundry Coke

Archer-Daniels-Midland Co., *"Furan Binder System."*

Tennessee . . Nov. 25 . . Wimberly Inn, Chattanooga, Tenn. . . A. P. Alexander, International Harvester Co., *"Inoculation —Its Advantages and Control."*

Texas . . Nov. 18 . . Caddo Hotel, Shreveport, La. . . H. Von Wolff, National Acme Co., Shalco Div., *"Shell Cores & Molds."*

Timberline . . Nov. 16 . . Oxford Hotel, Denver, Colo. . . H. W. Schwengel, Modern Equipment Co., *"New Developments in Water-Cooled Cupolas."*

Toledo . . Nov. 2 . . Heatherdowns Country Club, Toledo, Ohio . . G. Koren, Beardsley & Piper, Div. Pettibone Mulliken Corp., *"Shell Sand Coating & Shell Core for the Foundry".*

Tri-State . . Nov. 11 . . Blackwell, Okla.

Twin City . . Nov. 15 . . Jax Cafe, Minneapolis . . B. L. Ballard, Ingersoll-Rand Co., *"Uses and Abuses of Air Power." Joint Meeting with A. S. M.*

Utah . . Nov. 21 . . Provo, Utah.

Washington . . Nov. 17 . . Engineers' Club, Seattle.

Western Michigan . . Nov. 7 . . Fingers Restaurant, Grand Rapids, Mich. . . J. S. Schumacher, Hill & Griffith Co., *"Sand."*

Western New York . . Nov. 4 . . Sheraton Hotel, Buffalo, N. Y. . . G. DiSylvestro, American Colloid Co., *"Veining & Penetration."*

Wisconsin . . Nov. 11 . . Hotel Schroeder, Milwaukee . . R. Hottlet, *"Top Priority Issues for a New Administration." Management Night.*

DECEMBER

Birmingham District . . *No Meeting.*

Canton District . . Dec. 1 . . Mergus Restaurant, Canton, Ohio . . H. E. Figgie, Jr., *"Profitable Foundry Operations." Management Night.*

Central Illinois . . Dec. 10 . . American Legion Hall, Peoria, Ill. . . *Party.*

Central Indiana . . Dec. 5 . . Athenaeum Turners, Indianapolis . . J. S. Schumacher, Hill & Griffith Co., *"Sand Testing versus Molding Methods."*

Central Ohio . . Dec. 12 . . Seneca Hotel, Columbus, Ohio . . J. Barrabee, Hoover Ball & Bearing Co., *"Quality Control."*

Chesapeake . . Dec. 2 . . Engineers Club, Baltimore, Md. . . J. H. Schaum, Modern Castings, *"What's New in Metalcasting."*

Chicago . . Dec. 5 . . Chicago Bar Association, Chicago . . F. W. Less, Hooker Chemical Co., *"Shell Cores and New Shell Sand."*

PERMANENT MARKINGS END MIX-UPS!

USE

Markal Paint-stik® MARKERS

FOR

HEAT TREATING—ANNEALING—WELDING

ACID—ALKALI—CORROSIVE CONDITIONS

GREASY, HEAVILY OILED SURFACES

LUMBER—CERAMICS—GLASS

RUBBER—CLOTH—PLASTICS

Cold Marking down to —50°F. Hot Marking up to 2400°F.

Send today for literature and test samples.
State exact marking conditions.

PERMANENT • FADE-PROOF
WEATHERPROOF

The Mark of Quality . . . Markal

Markal COMPANY 3033 W. Carroll Avenue • Chicago 12, Illinois

Circle No. 147, Pages 143-144

shop tested

Spincraft
SKILL WILL DO IT ®

ladles last longer

Thousands of extra pours per ladle because they're stainless steel and specially reinforced.

NON SPILL SHAPE ELIMINATES WASTE!
75% LIGHTER THAN CAST IRON LADLES!

Available in all sizes, stainless and mild steel.

WRITE TODAY FOR COMPLETE DATA AND PRICES.

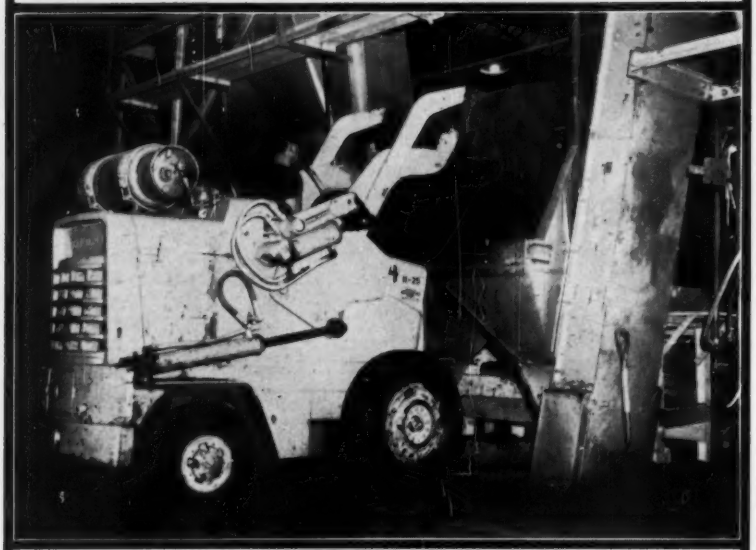
Spincraft
SKILL WILL DO IT ®

4127 W. State St.
Milwaukee 8, Wisconsin
Division 2-0730

Circle No. 148, Pages 143-144

← Circle No. 143, Pages 143-144

Sand handling system built



around 3 PAYLOADER® units

Davis & Furber Machine Company of North Andover, Mass., specializes in manufacturing textile machinery. Since 1952 this company has been a continuous user of "PAYLOADER" tractor-shovels on its foundry floor. Two Model HA's (2,000-lb. operating capacity) handle sand, move materials, remove cupola waste and the like. Recently the firm added Hough's new H-25 (shown) to its "PAYLOADER" fleet. This unit is used principally during the molding operation, bringing sand from storage to supply a 4-station sand system. At night it returns the sand from the muller to storage.

You will find that an H-25 "PAYLOADER" tractor-shovel will pay for itself very quickly in savings alone —

OPERATING CAPACITY — Its 2,500-lb. capacity is 25% greater than has ever been available in a tractor-shovel of this size. Yet, it shuttles around corners, through narrow aisles, doorways and crowded yards, up and down ramps with speed and safety.

MECHANICAL FEATURES — The H-25 has a full reversing, power-shift transmission (no clutching) with two speed ranges forward and two in reverse, torque converter drive, power-steering (6-ft. turning radius), power-transfer differential and fast, powerful hydraulic bucket control.

A HOUGH DISTRIBUTOR is nearby to show you how the Model H-25 or a larger "PAYLOADER" (up to 12,000-lb. operating capacity) can increase output and lower costs on your bulk handling requirements. Contact him today or return the coupon below.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
711 Sunnyside Ave., Libertyville, Ill.

☐ Send H-25 "PAYLOADER" data

☐ Other "PAYLOADER" units to 12,000 lb. operating capacity

Name _____
Title _____
Company _____
Street _____
City _____ State _____

11-A-2

Circle No. 149, Pages 143-144

Cincinnati District . . Dec. 17 . . Netherland Hilton Hotel . . *Christmas Party.*

Connecticut . . Dec. 14 . . Waverly Inn, Cheshire, Conn. . . . *Christmas Party.*

Corn Belt . . Dec. 17 . . Town & Country Restaurant, Lincoln, Neb. . . . *Christmas Party.*

Eastern Canada . . Dec. 2 . . Mount Royal Hotel, Montreal, Que. . . H. W. Schwengel, Modern Equipment Co., *"New Developments in Water-Cooled Cupolas."*

Metropolitan . . Dec. 9 . . Military Park Hotel, Newark, N. J. . . *Christmas Party.*

Michiana . . Dec. 12 . . Club Normandy, Mishawaka, Ind. . . Dr. O. A. Sander, Marquette University, *"The Foundry Silicosis Problem Can be Licked."*

Northern California . . Dec. 12 . . Spenger's Fish Grotto, Berkeley, Calif.

Northern Illinois & Southern Wisconsin . . Dec. 3 . . *Christmas Dinner Stag.*

Ontario . . Dec. 9 . . Royal Connaught Hotel, Hamilton, Ont. . . R. C. Shnay, Canada Iron Foundries, *"Recent Developments in the Production of Ductile Iron"*; G. M. Johnston, Neptune Meters Ltd., *"Ingot and Casting Quality in Bronze Alloys"*; A. Kavosi, Jr., Auto Specialties Mfg. Co., *"Pearlitic Malleable."*

Oregon . . Dec. 17 . . Multnomah Hotel, Portland, Ore. . . *Dinner Dance.*

Pittsburgh . . Dec. 19 . . Penn-Sheraton Hotel, Pittsburgh . . *Christmas Party.*

Rochester . . Dec. 6 . . Manger Hotel, Rochester, N. Y. . . J. A. Mueller, Carborundum Co., *"Snagging and Cut-Off."*

Saginaw Valley . . Dec. 1 . . Fischer's Hotel, Frankenmuth, Mich. . . W. Buel, Aristo Corp., *"Newest in Core Binders."*

St. Louis District . . Dec. 8 . . Edmonds Restaurant . . C. A. Sanders, American Colloid Co., *"Foundry of the Future."*

Texas . . Dec. 9 . . Houston Engineering & Scientific Society, Houston, Texas . . C. F. Lewis, Cook Heat Treating Co., *"Fundamentals of Heat Treatment."*

Toledo . . Dec. 7 . . Heatherdowns Country Club, Toledo, Ohio . . W. R. Oakley, Delhi Foundry Sand Co., *"CO_2 Process."*

Twin City . . Dec. 10 . . Midland Hills Country Club, St. Paul, Minn. . . *Party.*

Western Michigan . . Dec. 3 . . Muskegon Country Club, Muskegon, Mich. . . *Christmas Party* . . **Dec. 5** . . Black Angus Restaurant, Muskegon, Mich. . . W. R. Weaver, Modern Plastics & Pattern, Inc., *"New Applications in Pattern Making."*

Western New York . . Dec. 2 . . Sheraton Hotel, Buffalo, N. Y.

Wisconsin . . Dec. 9 . . Hotel Schroeder, Milwaukee . . *Christmas Party.*

Foundry Trade News

Cleveland Malleable Corp. . . . Cleveland, has acquired the assets and liabilities of the former Lake City Malleable Division. President of the new corporation is Charles Holland.

Tyler Pipe & Foundry Co. . . . Tyler, Texas, has installed a new pipe-making machine, marking completion of $500,000 expansion plans announced for 1960. This increases production of 10-ft long soil pipe by 30 per cent. An equal amount will be spent during 1961 for expansion of the sand spun pipe system. Cal-Tex Div., acquired in August by Tyler Pipe, has developed an on-and-off loader for trucks, and has installed a new machine shop.

Strategic Materials Corp. . . . has signed an agreement with Universal-Cyclops Steel Corp. for the joint development of the use of the Strategic-Udy process in production of materials for use in stainless steel and/or heat resisting alloys. Strategic Materials will build a $1,500,000 addition to its plant at Niagara Falls, Ontario with operations expected to start around the end of 1960.

National Engineering Co. . . . Chicago, has started a year-long tour of principal foundry cities in the United States and Canada with a mobile sand conditioning, handling, and reclaiming plant. The 37-foot trailer displays foundry equipment and techniques for shell molding, mixing, sand cooling, pneumatic transport, and sand reclaiming.

Orefraction Minerals, Inc. . . . has been acquired by Metal & Thermit Corp., New York. Metal & Thermit has diversified interests in chemicals, metals, alloys, minerals, and welding supplies and equipment.

National Crucible Co. . . . Philadelphia, has started construction of a new crucible manufacturing building that will add 50 per cent more floor space to the present area.

National Foundry Association . . . had a record attendance at its annual meeting in Chicago. Foundrymen were at this labor relations conference to sit in on informal discussions. Herman Menck, vice-president, Harnischfeger Corp., Milwaukee, reported on a first-hand study of European industry.

Canton Malleable Iron Co. . . . Canton, Ohio, a subsidiary of Penn Machine Co., Johnstown, Pa., has expended $500,000 to improve facilities and equipment. Purchased since its acquisition in Feb., 1959 are a new machine shop, melting furnace, coreroom, heating plant, sprinkler system, annealing oven, molder conveyor line, and a shipping room. New production facilities increase capacity from 35 to 100 per cent in various operations.

A. W. Baker, left, general manager, Chicago Hardware Foundry Co., North Chicago, Ill., welcomes Robert C. Lombard as new works manager. Lombard was formerly with Harsch Ebaloy Foundry Co., Rockford, Ill.

Mayor of Burton, Ohio, pours aluminum into sand mold at the Geauga Country Historical Society's exhibit in Burton. Former AFS Northeastern Ohio Chapter Chairman A. H. Hinton, Aluminum Co. of America, supervises the operation. Aluminum Co. of America participated in a demonstration of making aluminum castings in the county where the discoverer of the aluminum smelting process was born.

Mrs. Sidney E. McGinty presents check to Prof. Roy W. Schroeder, University of Illinois for the Sidney E. McGinty Metallurgical Memorial. Contributions which came from donations in lieu of flowers, form the initial funds which will be administered by the Foundry Educational Foundation as recommended by Mrs. McGinty, Prof. Schroeder and Chairman of the AFS Chicago Chapter.

Grants will be made to students enrolled in the foundry or cast metal laboratory courses at the University of Illinois Chicago undergraduate division. Contributions are being accepted for the Memorial fund and will be turned over to the Foundry Educational Foundation.

Let's Get Personal . . .

James R. Alexander . . . has been elected vice-president, sales, New Jersey Zinc Co., New York, succeeding **Robert G. Kenly,** who will assume new administrative duties. Alexander was formerly vice-president of sales for the Thermoid Div., H. K. Porter Co., Trenton, N. J.

Raymond E. Hess . . . associate executive secretary, American Society for Testing Materials, Philadelphia, has been named acting executive secretary and **Robert J. Painter,** executive secretary since 1952, is to be consultant to the executive secretary. Painter will continue as A.S.T.M. treasurer.

Bruce A. Crocco . . . has been appointed to the sales department of Danko Pattern & Mfg. Co. and Arlington Bronze & Aluminum Corp., Baltimore, Md.

W. H. Holtz . . . plant superintendent of the American Brake Shoe Co. Baltimore, Md., plant retired July 1, after 37 years service. A charter member of the Chesapeake Chapter and former chairman, he had been plant superintendent for the past 25 years. He was replaced by **Joe Bartemus,** formerly assistant superintendent at the Meadowlands, Pa., plant.

Robert P. Tibolt . . . has been elected president and chief officer of Eastern Gas and Fuel Associates, Boston, succeeding the late **Eugene H. Bird.**

Howard S. Bunn . . . has been elected to the newly created office of vice-chairman of the board and **Birny Mason, Jr.,** elected president of Union Carbide Corp. Bunn joined Union Carbide in 1922, became executive vice-president and a member of the executive committee in 1955 and president in 1958.

G. E. Smith . . . has been named as salesman in charge of the Detroit office of Union Carbide Metals Co., Div. Union Carbide Corp. He formerly served in the company's Cleveland district.

E. C. Troy . . . is vice-president, sales, National Engineering Co., Chicago. He is a past national AFS director and past chairman of AFS Philadelphia Chapter.

E. C. Troy

M. M. Rand

M. M. Rand . . . made manager, carbon and refractories, National Carbon Co., Div. Union Carbide Corp.

Dr. Harold W. Ruf . . . has been elected a vice-president of Grede Foundries, Inc., Milwaukee.

M. J. Lippincott . . . named general superintendent, Florence Pipe Foundry & Machine Co., Florence, N. J.

M. L. Lippincott

J. N. Wessell

J. N. Wessell . . . AFS Regional Vice-President, promoted to head production department laboratory at Puget Sound Naval Shipyard, Bremerton, Wash.

James K. Campbell . . . formerly manager, Canadian Pattern & Woodworking Co., Ltd., Montreal, Canada, is now secretary and treasurer, National Pattern & Woodworking Co., Ltd., Montreal.

Claude E. Robitalille . . . has been appointed works manager of the Doehler-Jarvis Div., National Lead Co. plant at Grand Rapids, Mich. **R. E. Moesser** has been named plant controller of Toledo, Ohio Plant 2; **R. Gordon Roesler** has been promoted to assistant sales manager at the Pottstown, Pa., plants.

J. Robert Von Bargen . . . has been appointed assistant eastern regional manager of Corn Products Div., Corn Products Sales Co. **Cleo Mikel** has been named district manager at Buffalo, N. Y., succeeding Von Bargen. Von Bargen joined Corn Products in 1936 and Mikel in 1934.

Anthony Demos . . . made manager, metallurgical sales, Frank Samuel & Co., Philadelphia.

Lester E. Wallace . . . promoted to general foreman, Sand Spun Pipe foundry, Florence Pipe Foundry & Machine Co., Florence, N. J.

L. E. Wallace

W. H. Wilkins

William H. Wilkins . . . becomes sales representative, George Sall Metals Co., Philadelphia.

Henry S. Rubenstein . . . is project supervisor, process metallurgy for Beryllium Corp., Reading, Pa. He formerly headed the development department, Bridgeport Brass Co. **Warren A. White** is now sales development engineer.

Robert M. Palmer . . . is field sales manager, Hevi-Duty Electric Co., Milwaukee.

Frank C. Riecks . . . has joined Lester B. Knight & Associates as senior associate and will head a new Detroit office.

F. C. Riecks

E. V. Blackmun

E. V. Blackmun . . . Aluminum Co. of America has received the 1960 Doehler award for his outstanding contributions to the advancement of the die casting industry as trustee of the Die Casting Research Foundation and chairman of the foundation's technical committee.

William E. Brandt, Jr. . . . has been appointed as a vibratory finishing process engineer for Pangborn Corp., Hagerstown, Md., and assigned to the Hagerstown office. Other assignments are **Barry L. Selack** to Cleveland and **John G. Weber** to Milwaukee.

James E. Heath . . . is now vice-president of manufacturing for Magnaflux Corp., Chicago. Heath previously was director of manufacturing for the Mechanical Div., General Mills, Inc., of which Magnaflux is a wholly owned subsidiary. Other men assigned to new posts include: **Hamilton Migel** was named vice-president for planning new products and product development; **A. E. Christensen,** manager of engineering and **Henry N. Nerwin,** chief engineer, electronics. **W. F. Reid,** treasurer and chief financial officer, takes on broader administrative functions.

Joseph P. Dunn . . . Newark, N. J., is eastern representative of N.F.A.

Kenneth M. Halvorson . . . is general superintendent, Belle City Malleable

K. M. Halvorson

H. T. Sheppard

Iron Co. and Racine Steel Castings Co., Racine, Wis. **Homer T. Sheppard** is superintendent, melting and metallurgy.

obituaries

Edward M. Cabaniss, 75, formerly president of Joseph Dixon Crucible Co., Jersey City, N. J., died Sept. 26 in Washington, D. C. He was with Joseph Dixon Crucible Co. for 36 years, joining as assistant to the president. He retired as board chairman last May.

Clarence H. Larkin, treasurer, General Foundry & Mfg. Co., Flint, Mich died Sept. 18. He had been with General Foundry for 33 years, serving the last 20 years as secretary-treasurer. He was active in AFS activities and in the local management executive group of the Gray Iron Founders' Society.

Martin W. Pohlman, executive vice-president, Pohlman Foundry Co., Buffalo, N. Y., died Sept. 7.

L. N. Shannon, senior vice-president, Stockham Valves & Fittings Co., Birmingham, Ala., and his wife died Sept. 28, when the auto in which they were riding collided with a trailer truck near **Helfin, Ala.**

L. N. Shannon

Shannon, 67, had spent his entire career with Stockham Valves & Fittings Co., starting as a checker in the final inspection department after graduation from Birmingham Southern College. He worked in all departments, rising steadily and in 1925 became vice-president of manufacturing, and in 1950, senior vice-president.

He served as an AFS Director, Vice-President, and was elected President in 1941. He was a member of the International Committee of Foundry Technical Associations and was president in 1953 when the International Foundry Congress was held in Paris, France. He received the grand medal of honor presented by the Ministry of Commerce and Industry of France on behalf of the Association Technique de Fonderie de France in that year.

In addition, Shannon was a founder and former president of the AFS Birmingham Chapter. He was also active in other technical societies and in community and youth work.

Which looks bigger to you?
in buying blast cleaning abrasives, too, low price is just an illusion
It's abrasive quality that really matters. Take hardness, for instance. Top quality Wheelabrator Steel Shot is the hardest steel shot ever made — almost 10 RC harder than lower priced steels. It hits harder, cleans faster, rebounds better to clean hard-to-reach areas. And it lasts much longer than softer abrasives.
For faster production and better finish — for true blasting economy, use high quality Wheelabrator Steel Shot. Prove it in your own equipment.
WRITE TODAY FOR THIS NEW HANDBOOK
of blast cleaning abrasive performance data, full of charts and facts to help you control abrasive consumption and cleaning costs. Write to Wheelabrator Corp., 630 S. Byrkit St., Mishawaka, Ind. In Canada, write to Wheelabrator Corp., Canadian Div., P.O. Box 490, Scarborough, Ontario.
WHEELABRATOR
STEEL ABRASIVES
Circle No. 160, Pages 143-144

New Products and Processes

What's new in foundry methods and equipment? Summaries of many are presented below. Circle corresponding number on free postcard, page 143. Mail it to us; we'll do the rest!

Portable Infrared Unit Suitable For Baking, Drying Applications

Portable infrared unit suitable for a variety of baking, heating, and drying applications, accommodates lamps up to 500 watts per socket with a total possible connected load of 24 kw.

Zoned switching provides maximum flexibility of heat output. The top four sections are adjustable to allow radiation to conform with product contours. Unit uses patented wide-angle gold-plated reflectors providing maximum heating efficiency. Fostoria Corp.

Circle No. 1, Pages 143-144

Photoelastic Stress Analysis Used In Either Sheet or Liquid Form

Photoelastic stress analysis technique may be used as sheet or in liquid form. It is applied to the actual part to be stress analyzed, eliminating the possible uncertain results obtained by stress analysis of plastic model parts, the maker reports.

The material is bonded to the part subjected to strain and the plastic follows the deformation of the part. When the plastic is deformed, it becomes birefringent—shows two sets of fringes under polarized light. Black fringes give the directions of principal strains while color fringes give the magnitude of principal strains in the part being stress analyzed. Instruments Div., Budd Co.

Circle No. 2, Pages 143-144

Core Shotting, Gassing Machines Feature One-Valve Operation

Core shooting and gassing machines reportedly give densest cores even with intricate design, lowest carbon dioxide consumption, and perfect clamping of core boxes and stripping of cores. All operations controlled by a main valve.

Special shoot head equipped with pneumatic cylinder for controlling the combination shooting and gassing plate. Suitable for large production of medium to large sized CO_2 cores which, due to their design, permit use of vertically split core boxes and mechanical separation of core boxes and cores, in one plane, by horizontal stripping of core box halves by clamping and stripping operations. Roperwerk

Circle No. 3, Pages 143-144

Consultation Service Available On Alloy Heat Treating

Free consultation service available on alloy heat treating methods for 17-4PH castings. Improperly controlled homogenization heat treatment in the 2000 F. range completely changes surface composition and properties.

Company will also help casters set up necessary protective controls when castings require homogenization heat treatment prior to solution annealing and hardening. WaiMet Alloys Co.

Circle No. 4, Pages 143-144

Combination Marker and Counter Cuts Hours from Inventories

Combination marker and counter cuts hours from inventories. Unit leaves small spot of ink and counter

clicks once each time it is depressed. Spots show where to resume counting, allows visual checking. Five colors allow coding. Van D. Mark Co.

Circle No. 5, Pages 143-144

Portable Sandblaster Requires No More Air Than Spray Gun

Portable sandblasting unit requires no more air than a production spray

gun. Blasting air does not travel through abrasive tank, insuring no entrapment of air line moisture. Abra-

sive enters air stream under pressure at inlet end of delivery hose, allowing the abrasive to accelerate through eight feet of hose.

Air supply is consumed at the rate of eight cubic feet per minute using 3/32-inch nozzle and air supply from a two horsepower compressor. A 5/32-inch nozzle consumes approximately 20 cubic feet per minute, requiring air supply from a five horsepower compressor. Unit operates with abrasives between 20 and 100 pound mesh. Handi-Blast Div., Hamill Mfg. Co.

Circle No. 6, Pages 143-144

Hardness Testers Feature Horizontal And Electromagnetic Models

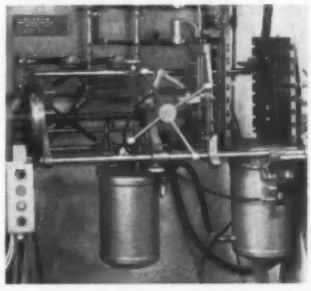
Hardness testers provide Rockwell hardness readings for all standard and special scales and use loading and penetrators in accordance with A.S.-M.E. and A.S.T.M. specifications.

Two models are offered: 1) a model which attaches electromagnetically to the material to be tested; and 2) a non-magnetic horizontal unit. Loading mechanisms use a beryllium copper spring, thus eliminating all weights, levers, and knife edges, providing permanent calibration. Both are light weight allowing use on the job. Advance Industries, Inc.

Circle No. 7, Pages 143-144

Multiple Operation of Shell Core Machines Possible with Automation

Automatic shell core machine produces cores on a controlled cycle, all operations are automatic and easily variable for quick change over. Operator has only to open and close core box and remove finished cores. Automatic, continuous sand supply allows one operator to handle two or three machines. Has face plates 14-1/2 x 18 in. with additional outlets for larger core boxes.



Uses natural, manufactured, or bottled gas, thermostatically controlled with heat applied directly to core box. Variable program of complete cycle allows drainage of most complicated cores. Dependable Shell Core Machines, Inc.

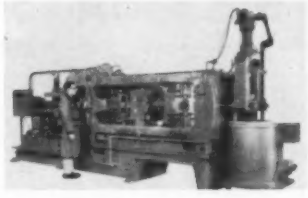
Circle No. 8, Pages 143-144

Betatrons Available For Lease; Accelerate X-raying Castings

Betatrons are now available under a lease agreement. The 25-million volt betatron provides speed in x-raying castings, weldments, and other sections and is able to penetrate thicker sections beyond the range of other non-destructive test equipment while maintaining excellent radiographic quality. Allis-Chalmers Mfg. Co.

Circle No. 9, Pages 143-144

Zinc Die Casting Machine Offers Unusual Amount of Die Opening



Zinc die casting machine reportedly offers twice the die opening of any with comparable tonnage. Delivers 450 tons of clamp while providing a die opening stroke adjustable from 8 to 30 inches. Produces deep draw zinc parts weighing to 15-1/4 tons.

Die set up is simple, consisting of a single hand crank die adjustment. Complete machine cycle at 8-in. die opening adjustment is 5.7 seconds, and at 30-in. adjustment, only 7.5 seconds. Pumping system uses a 30 horsepower motor and includes 2000 pound booster pump. Timed casting ejection is provided by bumpers. Hydraulic ejection and core-pull headers are optional. Lester-Phoenix, Inc.

Circle No. 10, Pages 143-144

Compact Electric Power Rolling Unit Gives Mobility to Floor Trucks

Eliminate manual pushing and dragging of heavy loads with compact rolling electric power unit. Converts lift trucks, platform trucks, floor cranes and mobile equipment to power-propelled operation. Wheel which

carries only the weight of the propulsion unit, automatically compensates for floor irregularities and maintains constant traction. Available in 3000 or 8000 pound capacities. Operates on 12 volt D.C. heavy duty motor. Colson Corp.

Circle No. 11, Pages 143-144

Ceramic Coatings Give Protection to Ladles, Sand and Shell Cores

Ceramic coating for permanent molds, dies, ladles, and related equipment may be applied by spraying, brushing or dipping. Forms a hard ceramic coating that will not spall, chip, or flake under normal conditions. Similar ceramic product available for sand and shell cores and molds. Possessing the same characteristics, it resists burn-in and penetration and simplifies shakeout. Applied by spray or dip, it can be used with ferrous and non-ferrous alloys. Unicast Development Corp.

Circle No. 12, Pages 143-144

Capital Cheers Chief

Crowds everywhere cheer Chief Keokuk and the winning Kemco ticket. Steel men and foundrymen hail Kemco Silvery as the superior form of silicon introduction. They know they can count on Kemco's campaign promise of economy and uniformity. This year, and every year, when they want Silicon . . . they choose KEMCO!

KEMCO SILVERY PIG IRON

SILICON METAL - OTHER FERROALLOYS

Kemco Silvery always melts evenly, handles easily by magnet or count, holds silicon loss to a minimum. Your choice of 60 lb. or 30 lb. pigs or 12½ lb. piglets in regular or alloy analysis for iron and steel production. Send for your copy of the free booklet, "For Lower Costs, Higher Quality Products". Be sure to check the performance of Kemco Silicon Metal in aluminum, too!

Keokuk Electro-Metals CO.

Division of Vanadium Corporation of America

Keokuk, Iowa • Wenatchee, Washington

Sales Agent: Miller and Company

332 S. Michigan Avenue, Chicago 4, Illinois
3504 Carew Tower, Cincinnati 2, Ohio
8230 Forsyth Blvd., St. Louis 24, Missouri

Circle No. 161, Pages 143-144

For The Asking

Build an ideal file for improvement and profit.
Circle numbers on literature request card, page 143, for manufacturers' publications.

Contract research . . . aimed at executives in industry who have decision-making responsibility for research and development programs. Describes step-by-step procedures of client and research institute relationship. Battelle Memorial Institute.
Circle No. 49, Pages 143-144

Abrasive materials . . . A listing of 14 topics dealing with the manufacture and use of abrasive materials. Qualified speakers have been assigned to each topic and a list of persons to contact to make arrangements for speakers is also included. Abrasive Grain Assoc.
Circle No. 50, Pages 143-144

Pallets and their uses . . . Digest size booklet illustrates different types of pallets and explains their uses. How to estimate pallet requirements, instructions for loading and standard loading patterns are given. Also suggests ways for safe pallet operations. The Raymond Corporation.
Circle No. 51, Pages 143-144

Electric lift trucks . . . Brochures on Models M-4 and M-3 give specifications, performance data and features of this helpful equipment for the modern castings producer. James Campbell Smith, Inc.
Circle No. 52, Pages 143-144

Loader . . . 9,000 lb carrying capacity unit, Model W-12, is described in 16-page brochure. Specifications are given along with on-the-job pictures and various features. J. I. Case Co.
Circle No. 53, Pages 143-144

Metalworking plants' heating problems . . . are discussed in 4-page bulletin and solutions are given. Subjects covered include: problems of proper warm air distribution in machinery-filled areas, replacement of air exhausted by fume removal systems,
Continued on page 145

Advertised Products November—1960

	Page Numbers
Abrasives, Blasting	2d Cover, 139
Aluminum Alloys	4
Chaplets	146
Coke	51, 134
Consulting Services	119
Core Plates	9
Crucibles	26
Ferro Alloys	10, 17, 3d Cover
Flasks & Jackets	123
Fluxes	11
Furnaces	12, 13, 132
Grinding Equipment	20
Investment Casting Equipment & Supplies	148
Laboratory Equipment	147
Ladles	2, 126, 135
Marking Devices	135
Material Handling Equipment	16, 136
Nickel Alloys	25
Patternmaking Equipment	147
Patterns	146
Pig Iron	22, 23, 28
Refractory Mold Materials	18
Sand Additives	145
Sand Binders—Bentonite	14, 15
Sand Binders—Cereal	6
Sand Binders—Fireclay	21
Sand Binders—Resin	120, 4th Cover
Sand Binders—Self-Curing	19
Sand Binders—Sodium Silicate	133
Sand Conditioning Equipment	1, 52, 53
Silvery Pig Iron	142

Yours . . . For Advancing Metalcasting

Are you looking for information on any of the subjects listed in the left hand column? Our MODERN CASTINGS advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new products items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

NOVEMBER 1960—1

Void through Jan. 1961

NEW EQUIPMENT AND MATERIALS

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205						
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206						
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207						
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208						
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209						
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210						
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211						
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212						
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213						
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214						
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215						
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216						

☐ I wish to subscribe to MODERN CASTINGS

ADVERTISED PRODUCTS

PLEASE PRINT

Name_____

Position_____

Company_____

Address_____

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 66, Sec. 34.9 P. L. & R. DES PLAINES, ILL.

Reader Service Dept.

MODERN CASTINGS

Golf and Wolf Rds.

Des Plaines, Ill.

Yours . . . For Advancing Metalcasting

Are you looking for information on any of the subjects listed in the right hand column? Our MODERN CASTINGS advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new products items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

PLEASE PRINT

Name_____

Position_____

Company_____

Address_____

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 53, Sec. 34.9 P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

NOVEMBER 1960—2

Valid through Jan. 1961

NEW EQUIPMENT AND MATERIALS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120

☐ I wish to subscribe to MODERN CASTINGS

ADVERTISED PRODUCTS

121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168
169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216

Advertised Products November—1960

	Page Numbers
Abrasives, Blasting	2d Cover, 139
Aluminum Alloys	4
Chaplets	146
Coke	51, 134
Consulting Services	119
Core Plates	9
Crucibles	26
Ferro Alloys	10, 17, 3d Cover
Flasks & Jackets	123
Fluxes	11
Furnaces	12, 13, 132
Grinding Equipment	20
Investment Casting Equipment & Supplies	148
Laboratory Equipment	147
Ladles	2, 126, 135
Marking Devices	135
Material Handling Equipment	16, 135
Nickel Alloys	25
Patternmaking Equipment	147
Patterns	146
Pig Iron	22, 23, 28
Refractory Mold Materials	18
Sand Additives	145
Sand Binders—Bentonite	14, 15
Sand Binders—Cereal	6
Sand Binders—Fireclay	21
Sand Binders—Resin	120, 4th Cover
Sand Binders—Self-Curing	19
Sand Binders—Sodium Silicate	133
Sand Conditioning Equipment	1, 53, 53
Silvery Pig Iron	142

Continued from page 142

and tempering of cold air inrush through shipping doors. L. J. Wing Mfg. Co.

Circle No. 54, Pages 143-144

X-Ray inspection of steel castings . . . technical bulletin discusses requirements for various classes of x-ray specifications, the relative extra costs, and the facilities available. Also a brief discussion of various classifications of steel castings uses requiring such inspection is included. Lebanon Steel Foundry.

Circle No. 55, Pages 143-144

Automatic gassing machines . . . data on these machines for core making by the CO_2 process are presented in 4-page bulletin. Pictured in installations, specifications of the units are also given. Anton Roper.

Circle No. 56, Pages 143-144

Load indicator . . . Test instrument for measuring loads from 0 to 10,000 lb. is described in two-page brochure. Unit is portable and measures pressure, torque, and thrust on metals, plastics, ceramics, etc. Research Products Co.

Circle No. 57, Pages 143-144

Conveying systems . . . bulletin illustrates and explains efficiency gains possible with low or high density conveying systems. Typical arrangements are shown as well as several installations. The Day Co.

Circle No. 58, Pages 143-144

Gamma radiography . . . Use of high specific activity cobalt 60 in industry is presented along with a chart on typical exposure times, specifications and details on components. Radionics Inc.

Circle No. 59, Pages 143-144

Regulators and portable manifolds . . . highlighted in 16-page catalog. Specifications and other pertinent information on regulators available for use with all industrial gases are given. Also includes details on portable manifolds for use with oxygen and acetylene. Inlet and outlet connections, recommended uses and installations are detailed. Linde Company

Circle No. 60, Pages 143-144

Scrap and conservation of natural resourses . . . booklet emphasizes use of iron and steel scrap by steel mills and foundries to help reduce waste of America's vital natural resources. Institute of Scrap Iron and Steel, Inc.

Circle No. 61, Pages 143-144

Release agent . . . Ready-to-use silicone solution for use in shell-molding and shell core blowing is detailed in preliminary product data report. General Electric Co.

Circle No. 62, Pages 143-144

Truck fleet leasing . . . merits and demerits of major plans are analyzed and costs compared with company ownership of truck fleets. Foundation for Management Research.

Circle No. 63, Pages 143-144

Vacuum report #4 . . . covers question, "when do you use an ion pump?" Various phases are included, such as; evaluation of present system, keeping the system clean, degassing, etc. Kinney Vacuum Div., The New York Air Brake Co.

Circle No. 64, Pages 143-144

Corrosion control . . . paper on the galvanic relationships between aluminum alloys and magnesium alloys demonstrates some of the principles determining compatibility of these alloys and use of the principles to control corrosion. The Dow Metal Products Co.

Circle No. 65, Pages 143-144

Precision steel castings . . . produced in ceramic molds is topic of new bulletin. Relative advantages of the process are presented. Lebanon Steel Foundry.

Circle No. 66, Pages 143-144

Railroad car shaker . . . new low-frequency vibration shaker mechanism for fast, economical unloading of hopper

YOU'LL MAKE BETTER CO_2 CORES AND MOLDS IF YOU USE THESE GOOD **STEVENS** PRODUCTS—

- *Steveco CO_2 Binder*
- *Fastick Liquid Core Paste*
- *Igni-Bond Core and Mold Wash*
- *Slick-Seal Mudding Compound*
- *#100 Carbon*
- *Stevens Sand Conditioner*

SEND COUPON BELOW FOR NEW 12-PAGE BOOKLET TELLING EXACTLY HOW THESE STEVENS PRODUCTS CAN BE USED FOR BEST RESULTS IN YOUR CO_2 PROCESS.

frederic b. **STEVENS,** inc.
1800 - 18th Street, Detroit 16, Michigan

Please send me my free copy of your latest brochure, "The CO_2 Process for Making Cores and Molds".

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

Circle No. 162, Pages 143-144

bottom cars is shown in 6-page brochure. Link-Belt Co.

Circle No. 67, Pages 143-144

Stacker cranes . . . in warehousing of steel bar stock, dies, etc. are shown on-the-job. Features, advantages and specifications are given. The American MonoRail Co.

Circle No. 68, Pages 143-144

Superalloys . . . data sheet on cobalt-base and nickel-base lists physical and mechanical properties, corrosion resistance, thermal treatment, fabrication, available shapes, and applications of 13 alloys. Cobalt Information Center.

Circle No. 69, Pages 143-144

Olivine sand and flour in the foundry . . . booklet gives properties; highlights how it helps eliminate casting defects; and outlines foundry practice. E. J. Lavino and Co.

Circle No. 70, Pages 143-144

Foundry sand coating . . . technical bulletin describes new flaked phenol-formaldehyde synthetic resin, gives specifications, application procedure and lists suggestions for use. Reichhold Chemicals, Inc.

Circle No. 71, Pages 143-144

Aluminum furnace brick . . . 8-page technical publication outlines characteristics and applications for aluminum melting furnace brick and mortar for reverberatory furnaces. Refractories are low in silica and high in alumina content. Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Sales, Inc.

Circle No. 72, Pages 143-144

Scale models . . . use of these three-dimensionals in expansion programs, plant design, layout, and construction are described. Also their role in improving production methods, process and material flow, in industrial training and maintenance are given. Knight Models, Inc.

Circle No. 73, Pages 143-144

Dustless wood flour . . . literature covers product which is identical with regular line except that it is free from dust diffusion. Reportedly assists clay, stabilizes varying strength of sand in pour, improves flowability and shakeout. Penn-Rillton Co.

Circle No. 74, Pages 143-144

Graphite electrode . . . data covers typical chemical and physical properties of various grades and sizes. Electrode Div., Great Lakes Carbon Co.

Circle No. 75, Pages 143-144

Cold-setting rubber mold compounds . . . advantages and how to use them for gypsum and portland cement applications, is explained in four-page illustrated booklet. Material said to be tough, flexible, chemically and mechanically stable. Smooth-On Co.

Circle No. 76, Pages 143-144

Equipment catalog . . . lists company items and government and industrial surplus products with engineering specifications, technical drawings and suggested uses. New 64-page catalog covers electrical, hydraulic, and mechanical items. Groban Supply Co.

Circle No. 77, Pages 143-144

Corrosion computer . . . lists more than 100 chemical agents and their effects on brass and naval bronze, silicon bronze, monel, stainless types, copper, and aluminum. Color-coded windows indicate resistance in four categories. H. M. Harper Co.

Circle No. 78, Pages 143-144

Welding alloys . . . catalog and instruction manual, 56 pages, covers welding, brazing and welding, brazing and soldering alloy and flux. Lists physical properties, major uses, detailed application instruction and techniques. Illustrated with charts and tables for alloy selection and properties. All-State Welding Alloys Co.

Circle No. 79, Pages 143-144

SCIENTIFIC
PRESSURE CAST
MATCHPLATES
"BUILT WITH EXTRA CARE"
Not a single matchplate leaves the Scientific Plant without rigorous 7-point inspection.
Better equipped than ever before, we are continuing to progress and thank our many customers.
THE SCIENTIFIC CAST PRODUCTS CORP.
1390 East 40th Street • Cleveland 3, Ohio

Circle No. 163, Pages 143-144

WHY POUR YOUR PROFITS AWAY?
save up to 50% on chaplets
Buffalo
ECONOMY
CHAPLETS
Now you can save up to 50% on chaplet costs with Buffalo Patented Angle Stem and Double Angle Chaplets. They burn in more easily, without chilling. They are thoroughly coated to assure instant fusion with molten metal. And the unusual strength of the one-piece design permits fabrication in thinner gauges. All these features mean savings to you.
Furnished in a complete line of sizes and gauges, Buffalo Economy Chaplets are available in tinned steel, Monel, stainless steel and copper. Why not give them a trial? It costs only pennies to find out how many dollars you will save.
Write for literature on Economy Chaplets. For information on the complete "Buffalo" line, request Catalog No. 20.
MANUFACTURED BY
Combined SUPPLY & EQUIPMENT CO., INC.
211 Chandler St., Buffalo 7, N. Y.

Circle No. 164, Pages 143-144

Future Meetings and Exhibits

Nov. 1-3 . . Investment Casting Institute, Annual Meeting and Design Clinic. Chicago.

Nov. 1-3 . . Material Handling Institute, Central States Show. Kentucky Fair & Exposition Center, Louisville, Ky.

Nov. 8-11 . . Society of Die Casting Engineers, National Die Casting Exposition & Congress. Artillery Armory, Detroit.

Nov. 14-16 . . Steel Founders' Society of America, Technical & Operating Conference. Carter Hotel, Cleveland.

Nov. 14-18 . . American Society of Tool & Manufacturing Engineers, Semi-Annual Meeting and Western Tool Show. Sports Arena and Ambassador Hotel, Los Angeles.

Nov. 27-Dec. 2 . . American Society of Mechanical Engineers, Annual Meeting. Statler Hotel, New York.

Nov. 30-Dec. 2 . . Metallurgical Society of AIME, Electric Furnace Conference. Morrison Hotel, Chicago.

Dec. 6-7 . . Foundry Facings Manufacturers Association, Annual Meeting. New York.

Dec. 6-8 . . National Association of Manufacturers, Annual Meeting. Waldorf-Astoria Hotel, New York.

Dec. 12-14 . . Material Handling Institute, Annual Meeting. Savoy-Hilton Hotel, New York.

1961

Feb. 9-10 . . AFS Wisconsin Regional Foundry Conference. Schroeder Hotel, Milwaukee.

Feb. 16-17 . . AFS Southeastern Regional Foundry Conference. Read House, Chattanooga, Tenn.

Feb. 26-March 2 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Annual Meeting. Ambassador and Chase-Park Plaza Hotels, St. Louis.

March 1-2 . . Malleable Founders Society, Technical & Operating Conference. Wade Park Manor, Cleveland.

March 11-14 . . Steel Founders' Society of America, Annual Meeting. Drake Hotel, Chicago.

April 10-12 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Open Hearth Steel Conference. Sheraton Hotel, Philadelphia.

April 18-20 . . Foundry Educational Foundation, Annual College-Industry Conference. Statler-Hilton Hotel, Cleveland.

April 18-20 . . American Welding Society, Annual Meeting and Welding Show. Commodore Hotel and Coliseum, New York.

May 8-12 . . AFS 65th Castings Congress & Exposition. Brooks Hall, Civic Auditorium, San Francisco.

May 10-12 . . National Industrial Sand Association, Annual Meeting. The Homestead, Hot Springs, Va.

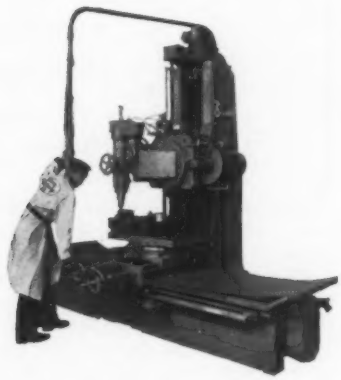
June 8-9 . . Malleable Founders Society, Annual Meeting. The Broadmoor, Colorado Springs, Colo.

June 15-16 . . AFS Chapter Officers Conference. LaSalle Hotel, Chicago.

June 22-24 . . AFS Penn State Regional Foundry Conference. Penn State University, University Park, Pa.

June 25-30 . . American Society for Testing Materials, Annual Meeting. Chalfonte Haddon Hall, Atlantic City, N. J.

Cuts cast iron, wood and aluminum patterns



"OLIVER" No. 104 PATTERN MILLER

Adapts easily to cutting wide variety of materials in pattern production. Fine design provides ease of operation. Built to assure maximum rigidity and high accuracy. Complete details and specifications upon request.

OLIVER MACHINERY COMPANY
GRAND RAPIDS 2, MICHIGAN

Circle No. 166, Pages 143-144

Polish metallurgical samples easier, better, more uniformly with . . .

SYNTRON

LAPPING-POLISHING MACHINES

—whether it's one or a number of specimens to be polished, SYNTRON Vibratory Lapping-Polishing Machines will produce a metallographic finish for an electron microscope or brush analyzer examination.

Gentle, electromagnetic vibration moves the specimens smoothly around the pan, over abrasive cloth or polishing felt cloth. Abrasive and felt cloths are removable.

SYNTRON Lapping-Polishing Machines are easy to install, easy to operate, easy to maintain.

Write for detailed literature today

SYNTRON COMPANY
Quality Equipment Since 1921
545 Lexington Ave. Homer City, Penna.

Circle No. 167, Pages 143-144

New Books for You . . .

Engineer's Vest Pocket Books . . . 192 pages. Ottenheimer Publishers, Inc., 4805 Nelson Ave., Baltimore, Md. Contains 250 main items, 47 charts, an alphabetical index, index of charts and tables, as well as 12 marginal indexed headings: mathematics, building, mechanics, heat, hydraulics, pipes, electricity, surveying, costing, mining, chemistry, and miscellaneous data.

Chart of Accounts and Cost Dictionary . . . Non-Ferrous Founders' Society, 1604 Chicago Ave., Evanston, Ill. 20 pages. 1960. Publication is supplement No. 1 to "Basic Cost Principles for Non-Ferrous Foundries," and designed to facilitate adoption and installation of either the simplified or expanded cost system. It also aids in distribution of expense items to proper department and accounting classifications. The chart of accounts lists and designates account numbers for over 60 balance sheet and nearly 100 income statement accounts. In the dictionary section, some 350 items common in non-ferrous foundries are broken down into three classifications: wages and salaries, material and supplies; and miscellaneous expenses. For each item the appropriate department (including overhead) is given as well as the correct amount for both the simplified and the expanded system.

Large Scale Phase Diagrams . . . American Ceramic Society, 4055 N. High St., Columbus 14, Ohio. Ten phase equilibrium diagrams of oxide systems which can be interpolated to 0.1 per cent. Diagrams are on a 500 mm equilateral triangle. Base triangle is printed in light blue and has 5 mm divisions, each representing 1 per cent in composition. Temperature contours are in green, compositions in red, and boundry curves and primary phases in black. Printed on 19-1/2x23-1/4 inch map paper.

Steel Foundries of North America . . . Steel Founders' Society of America, 606 Terminal Tower, Cleveland. Pocket-sized directory published bienially containing all steel foundries in the United States, Canada, and Mexico with listing of their officers and directors.

Accident Prevention for Steel Foundry Executives . . . Steel Founders' Society of America, 606 Terminal Tower, Cleveland. Second printing. Book was originally published in 1956, prepared by the safety committee.

A Visit with 500 Die Cast Plants . . . E. A. Day. 600 pages. American Charcoal Co. 1960. Contains 375 illustrations and drawings, 125 separate chapters, and 45 technical tables. More than 100 operating men, executives, engineers, consultant, and supplier personnel have contributed solutions for everyday die casting problems. Book is written so that solutions are understandable to both shop personnel as well as management.

Basics of Induction Heating . . . Chester A. Tudbury. Vol I, 140 pages; Vol II, 144 pages. John F. Rider Publisher, Inc., 116 W. 14th St., New York. 1960. Presents the fundamentals underlying induction heating as well as the application of equipment through the "pictured text" approach. Describes and explains the operation of more common types of industrial induction heating machines and gives material to assist in developing a quantitative understanding of new applications. Also deals with electrical and thermal aspects in detail and touches more briefly upon some of the mechanical problems associated with fixturing. Intended for high school students, technical institutes, and industrial training courses and is useful for shop men engaged in operating, maintaining, and tooling induction heating equipment.

COSTS LESS!
CERAMIC SHELL MOLDS
CUT PROCESS TIME 50%
. . . MATERIAL COST 40%
NALCAST SYSTEM
for
- Simpler methods!
- Larger castings!
- Closer tolerances!
- Saving time and money!

Phone or write us about the
NALCAST SYSTEM.
For your general investment casting requirements we recommend—
SAUNDERS BLUE WAX • SHERWOOD WAX INJECTION PRESSES • ECCO HIGH FREQUENCY MELTING EQUIPMENT
and other production proven products.
Send for Complete Catalog #56.
ALEXANDER SAUNDERS & CO., Inc.
95 Bedford St., New York 14
Tel. — WAtkins 4-8880

Circle No. 165, Pages 143-144

Economist Forecasts Gradual Recovery

"The current business situation is only a difficult period which must be faced and converted to opportunities for success," advised Dr. John K. Langrum, Business Economics, Inc., at a recent meeting of the National Foundry Association.

In his economics forecast, Langrum said "There won't be a sharp drop, just a sideways movement at a low level of productivity."

"At the beginning of 1960," he said, "inventories of all manufactured goods were being built up at the rate of $12 billion per year. In a major inventory adjustment in July, this rate dropped to zero." He observed that the economy as a whole has run remarkably well in spite of this negative influence of big inventory cutbacks. Evidence of this is reflected in the national gross product which is at a record high.

Fundamental problems still face the nation. One is the deterioration in the corporate profit margin as a result of the pressure of labor costs and inability to raise profits. These are marring what would normally be a prosperous era. As competition for markets increase, profits will become thinner.

He also warned against too much reliance on a population growth as a boon to industrial prosperity, pointing out that recession can flourish in spite of increased population.

Dr. Langrum explained that the excessive optimism for 1960 was aided in part by such glamorous expressions as the "Soaring 60s" and the "Golden 60s."

The bubble of enthusiasm was exploded early in the year when the steel industry hit a steady downward trend. The 1959 steel strike had created an artificial, high demand rate needed to replace drastically depleted inventories.

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid. **Positions Wanted** . . 10c per word, 30 words minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 words. **Display Classified** . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

DIE CASTING ENGINEER—Medium sized northeastern company in electro-mechanical field presently buying some die castings, desires engineer capable of working with design engineering, purchasing and manufacturing to further use of die castings in company products. Must be thoroughly versed in all phases of die casting operation. Eventually company may establish own die casting facilities and engineer selected must be capable of handling this project. Send resume to **Box K-108, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOREMAN PERMANENT MOLD . . . Good opportunity for experienced man who knows permanent mold work and can handle men, to grow with rapidly expanding aluminum foundry and product manufacturer. Replies held in confidence. Reply **Box K-107, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY EQUIPMENT ENGINEER . . . Large midwest foundry machinery manufacturer has opportunity for aggressive design engineer with B.S.M.E. degree or equivalent. Actual foundry experience essential and applicant must be capable of sound original design with complete follow through. State experience, qualifications, education, age, salary requirements and references. **Box K-101, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

INDUSTRIAL ENGINEER—Exceptional opportunity for graduate industrial engineer with a minimum of 3 years experience capable of developing, maintaining and supervising a job cost system for the control of labor and process costs. Midwest Steel Foundry. Excellent working conditions. Salary commensurate with experience and background. Please furnish a complete resume of experience and education. All replies will be treated confidential. **Box K-105, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

GOOD FOUNDRYMEN

when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.

Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact: John Cope

DRAKE PERSONNEL, INC.

29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

PLANT ENGINEERS

Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

CORE ROOM FOREMAN

$650 to $750

Excellent opportunity for advancement in a young growing organization, interested in man with top management potential. Client assumes all expenses. Contact Bill Newell in confidence.

MONARCH PERSONNEL

28 East Jackson Blvd. Chicago 4, Illinois

JR. FOUNDRY METALLURGIST

$7,200 to $8,400

Promotable type young man to join rapidly expanding organization that places a great deal of emphasis in engineering proficiency. Client assumes all expenses. Contact Bill Newell in confidence.

MONARCH PERSONNEL

28 East Jackson Blvd. Chicago 4, Illinois

MAINTENANCE GENERAL FOREMAN to head plant maintenance department in a leading eastern steel foundry. Should have at least five years experience in foundry or steel mill field and be well versed in modern day maintenance management techniques. Mechanical or electrical engineering graduate preferred but will consider others of proper qualifications. Position is one of real challenge, offers optimum opportunity and pays well. Send detail resume to **Box K-103, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PLANT MANAGER . . . Small steel foundry in northern Ontario planning to expand requires man with thorough knowledge all phases foundry business. Electric arc furnace experience desirable. **Box K-104, MODERN CASTINGS, Golf & Wolf Rds., Des Plaines, Ill.**

POSITIONS WANTED

FOUNDRY MANUFACTURERS AGENT covering Iowa, Western Illinois, Nebraska, seeks several additional foundry lines. Interested in lines non-competitive to core oils and foundry washes. Quick action assured by twenty-year successful record selling foundries. Box K-100, **MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ACID ELECTRIC MELTER, 45 years of age, 25 years experience. Some induction experience. Carbon, high and low alloy, stainless, tool steels and alloy irons. Presently employed. Desire similar position with greater challenge. Qualified to handle complete melting department. **Box K-106, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ESTABLISHED REPRESENTATIVE

WANTS—Pattern shop—Detroit areas—capable of wood and metal jobs, 5 figures. I have good following. WANTS—Malleable foundry—and be exclusive agency in Detroit and southeastern Michigan. Technically trained. 10 years sales experience pattern and castings. **Box K-102, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

ONE MODEL 3 UNIT DRIVE SIMPSON MULLER—with Bucket Loader, Double Discharge Hoppers, Mill Belt, Bucket Elevator, National System Aerator, 14-ft. long Prepared Sand Conveyor, 50 ton Sand Storage Bin. All in good condition. **Address Box H-110, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

QUALITY EQUIPMENT

SAVE AT LEAST 50%

MELTING & HEAT TREAT UNITS
BLAST CLEANING
MOLDING MACHINES
SAND CONDITIONING

Your largest dealer for all foundry equip't.

UNIVERSAL Mach'y & Equip't Co.
Box 873, Reading, Pa. FRanklin 3-5103

$7,000.00 worth of pattern shop supplies, perishable items and tools, equipment and machines (drillpress, disk sanders, lathes, saws, shaper) list on request. Sacrifice in bulk. T. Schnorberger, Monroe, Michigan. CHerry 10320

WANTED TO BUY

BACK VOLUMES — Wanted to buy for cash of foundrymen, TRANSACTIONS American Foundrymen's Society and other scientific technical Journals. **Walter J. Johnson, Inc., 111 Fifth Avenue. New York 3, N. Y.**

ENGINEERING SERVICES

EARL E. WOODLIFF
Foundry Sand Engineer
Consulting . . . Testing
14611 Fenkell (5-Mile Rd.)
Detroit 27, Michigan
Res. Phone VErmont 5-8724

FOUNDRY CONSULTANT — NON-FERROUS Sand casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings — **ED JENKINS, West Palm Beach, Florida — PHONE: Temple 2-8685.**

Advertisers This Issue

Ajax Magnethermic Corp.	132
Archer-Daniels-Midland Co.	19
Baroid Chemicals, Inc.	14, 15
Beardsley & Piper, Div. of Pettibone Mulliken Corp.	52, 53
Carver Foundry Products Co.	1
The Cleveland Flux Co.	11
Combined Supply & Equipment Co.	146
Corn Products Co., Industrial Div.	6
Durez Plastics Div. Hooker Chemical Corp.	120
Grinding & Polishing Machinery Corp.	20
Hanna Furnace Corp., Div., National Steel Corp.	22, 23
Hevi-Duty Electric Co.	12, 13
The Frank G. Hough Co.	136
International Minerals & Chemical Corp., Eastern Clay Products Dept.	21
The International Nickel Co., Primary Nickel Dept.	25
Johns-Manville Corp., Industrial Insulations Div.	9
Keokuk Electro Metals Co.	142
Lester B. Knight & Assoc., Inc.	119
Koppers Co., Inc.	134
Markal Company	135
Metal Blast, Inc.	2nd Cover
Modern Equipment Co.	2
Ohio Ferro-Alloys Corp.	3rd Cover
Oliver Machinery Co.	147
Philadelphia Quartz Co.	133
Pickands Mather & Co.	28
Reichhold Chemicals, Inc.	4th Cover
Reynolds Metals Co.	4
Alexander Saunders & Co., Inc.	148
Scientific Cast Products Corp.	146
Semet-Solvay Div., Allied Chemical Corp.	51
Spincraft, Inc.	135
Sterling National Industries, Inc.	123
Frederic B. Stevens, Inc.	145
Syntron Company	16, 147
Union Carbide Metals Co., Div., Union Carbide Corp.	17
Universal Clay Products Co.	18
Vanadium Corp. of America	10
Vesuvius Crucible Co.	26
Wheelabrator Corp.	139
Whiting Corp.	126

How's Business . . .

Going Up . . .

Present estimates indicate that total shipments of U. S. aluminum producers and fabricators will make 1960 the second best volume year in the industry's history. Total for the year should be approximately 4.7 billion pounds, compared with 4.9 billion pounds in the peak year of 1959. These figures include both domestic and export shipments.

Recently reported dollar volume of orders for material handling equipment in August showed a jump of nearly 6 points over orders reported in July. Using 1954 as the statistical base year and 100 as the monthly average, August bookings stand at 131.33. The dollar volume of orders in July was 126.79. Bookings in the industry for the first eight months of the year are only about 1.7 per cent off the level recorded for the same period last year.

Recent weeks have seen an upturn in savings deposits. Reversing the June quarter trend when net of individual new savings dropped to $1 billion. It was $4.3 billion in the first quarter of this year. In August, however, savings and loan associations across the country had a gain of $485 million in savings, or 21% more than in August last year.

Steel production for the year 1960 should be at about 106 million tons for the nation's industry as a whole. This would surpass the 93.4 million tons turned out in 1959, but will be somewhat lower than 120 to 130 million tons forecast a year ago.

The industry, however, will have to average about 65 per cent of capacity for the last third of the year. Predictions are for a capacity in the final quarter of between 55 percent and 65 percent of capacity.

Some 422,700 U. S. built cars were sold by auto dealers during September. This is almost 21% more than last year. This surge brings the car industry out of the "dumps" which lasted two months.

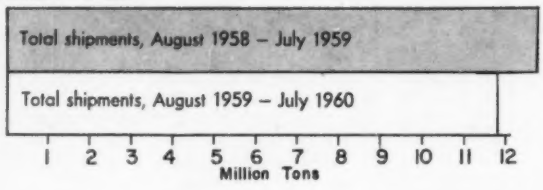
Defense spending stands at $431

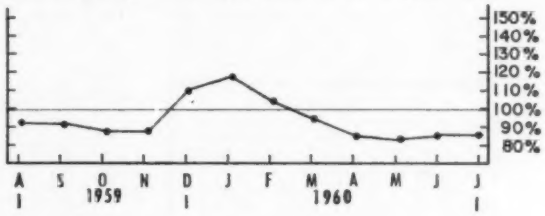
Trends in Metalcasting Shipments

Statistics from Bureau of the Census, U. S. Department of Commerce

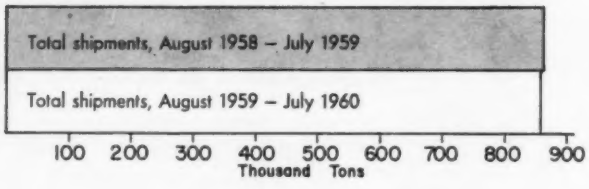
Monthly shipments compared with a year ago.

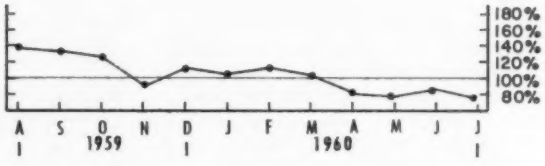
GRAY IRON



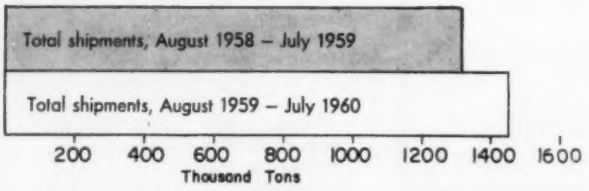


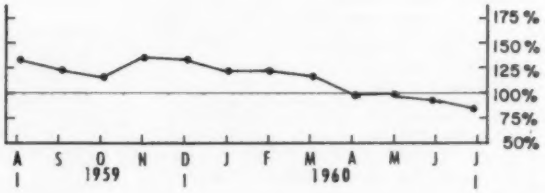
MALLEABLE IRON


Total shipments, August 1958 – July 1959
Total shipments, August 1959 – July 1960
100 200 300 400 500 600 700 800 900
Thousand Tons



STEEL


Total shipments, August 1958 – July 1959
Total shipments, August 1959 – July 1960
200 400 600 800 1000 1200 1400 1600
Thousand Tons



million higher than the January estimate of $45.6 billion. The jump includes an additional $149 million for the B-70 bomber and other aircraft. Too, the Government will spend $87 million for missile procurement, another $37 million for ships, and $150 million for satellite and missile research. Military maintenance, construction, defense stockpiles and atomic energy spending has been reduced.

Troubles . . .?

Various producers of a variety of consumer items report slower collections. Some clients are taking five to 10 days longer to pay than they did last year. Credit departments say they have to stay "right on top of customers to collect." Trend is attributed to the fact that it is now a buyer's market and longer credit must be extended to stay in business.

Controversy . . .

The recent accusation of 13 Senators, headed by Senator Joseph S. Clark, that the U. S. Department of Commerce has withheld from the public a special secret study on the economy has been answered by Secretary of Commerce Frederick H. Mueller.

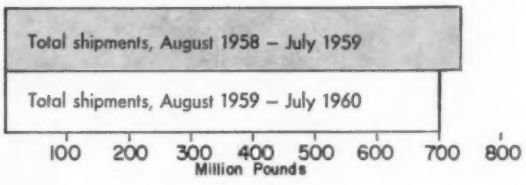
Secretary Mueller stated that the Commerce Department has not made a report to the President or anyone that the economy is in recession, nor has the Department completed or announced the Gross National Product compilation for the quarter ending September 30.

The Secretary further stated that the "honorable Federal career economists, and statisticians . . . never have they withheld the truth—favorable or unfavorable—nor do Department officials ever suggest that they suppress or slant these reports."

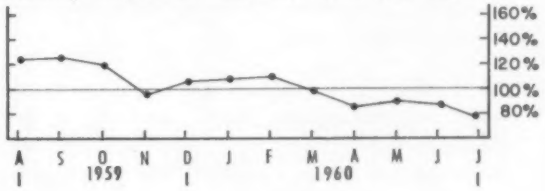
Personal income is predicted to rise to $405 billion, well above last year's total of $383.3 billion.

Based on the 1947-49 monthly average of 100, orders for new foundry equipment stood at 92.4 for August this year.

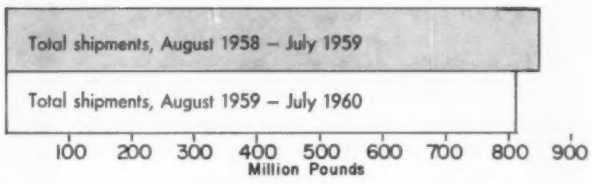
ALUMINUM

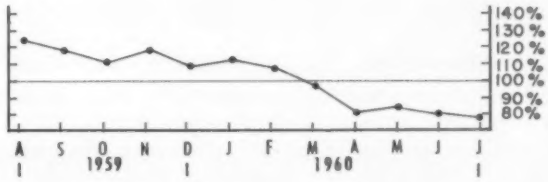

Total shipments, August 1958 – July 1959
Total shipments, August 1959 – July 1960
100 200 300 400 500 600 700 800
Million Pounds

Monthly shipments compared with year ago.

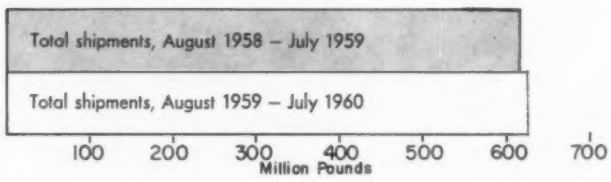


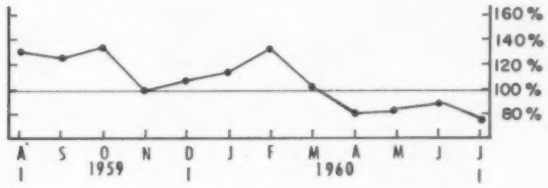
COPPER


Total shipments, August 1958 – July 1959
Total shipments, August 1959 – July 1960
100 200 300 400 500 600 700 800 900
Million Pounds

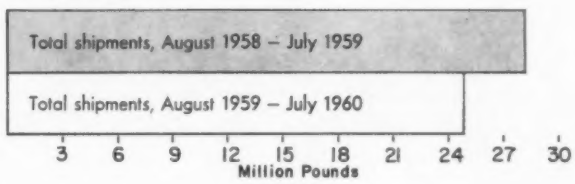


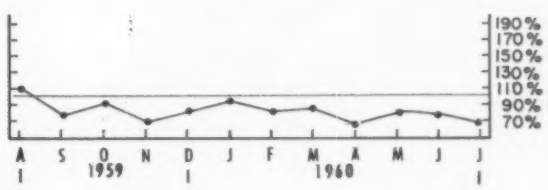
ZINC





MAGNESIUM





The Editor's Forum . . .

Furfural . . . is the new magic word being added to foundrymen's vocabulary. A by-product of the cereal industry, furfural alcohol has been discovered to have remarkable sand binding properties particularly suited for coremaking. Jobbing shops are using it as an air-setting binder for large cores. Production foundries find it suited to mass production of small cores in heated boxes. Cores blown into 400 F. boxes cure in 10 to 20 seconds. A number of the big automotive and farm implement manufacturers are in limited production with the new process. Watch MODERN CASTINGS for more details soon.

More aluminum engines . . . are appearing in the 1961 cars. Aluminum blocks are used in the Oldsmobile F-85, American Motor Rambler, and Buick Special. Other uses for aluminum in addition to engines will boost automotive consumption about 14 per cent over 1960—for a total of about 379 million pounds. Average in 1961 expected to reach about 62 pounds of aluminum per car.

Value analysis . . . is a scientific method of getting the same or better performance from a product at lowest cost. A team composed of men from purchasing, engineering and manufacturing meet with vendors, such as casting sales engineers, to determine the best material and way to fabricate parts. Special training seminars are being held by manufacturers to train their employees to think in terms of value analysis. Allis-Chalmers Mfg. Co. is one such company that is educating hundreds of engineers to this new thought process. Once trained to value analysis, employees follow a step-by-step procedure to scrutinize every part and every operation in the manufacture of a product. Casting salesmen now find the welcome mat out and doors open since they are an important part of the value analysis team. Here's a golden opportunity for metalcastings to get a fair trial. Just be sure your sales engineers are prepared to present a strong story justifying the use of castings.

Silent shakeout . . . is more than a dream to this normally noisy foundry operation. In a recent visit to International Harvester's Farmall Works in Rock Island, Bill Salzmann demonstrated how they had solved this problem. The steel bars forming shakeout grates have a 1¼ inch layer of rubber attached to top surface. Drag flasks slide onto this surface after the castings have been removed. Sand is silently vibrated out of the flasks without the usual nerve-wracking clatter. After one month's service there is no visual wear on the rubber and the critical parting line surface of the flasks is protected from damage. Here's another important victory in the foundry industry war-on-noise.

Take a close look . . . at your cleaning room activities. Here's where casting costs pyramid. The cleaning room is also your barometer that measures sloppy practices in the plant. In a recent conversation, Leo Carr, Precision Metalsmiths, Inc., Cleveland, explained how they were able to reduce cleaning department personnel from 30 down to 6. Their new poly-shell process has accounted for this spectacular fringe benefit. Poly-shell is a technological break-through using polystyrene patterns and ceramic shell coatings for production of investment castings.

If it moves . . . paint it orange. This is the silent visual safety siren that warns workers to move with caution around machinery with orange colored parts. John Deere Malleable Works, East Moline, Ill., has found this practice an inexpensive but effective safety device on conveyor systems and molding machines.

Jack Hickson

SOME FOUNDRY PROBLEMS

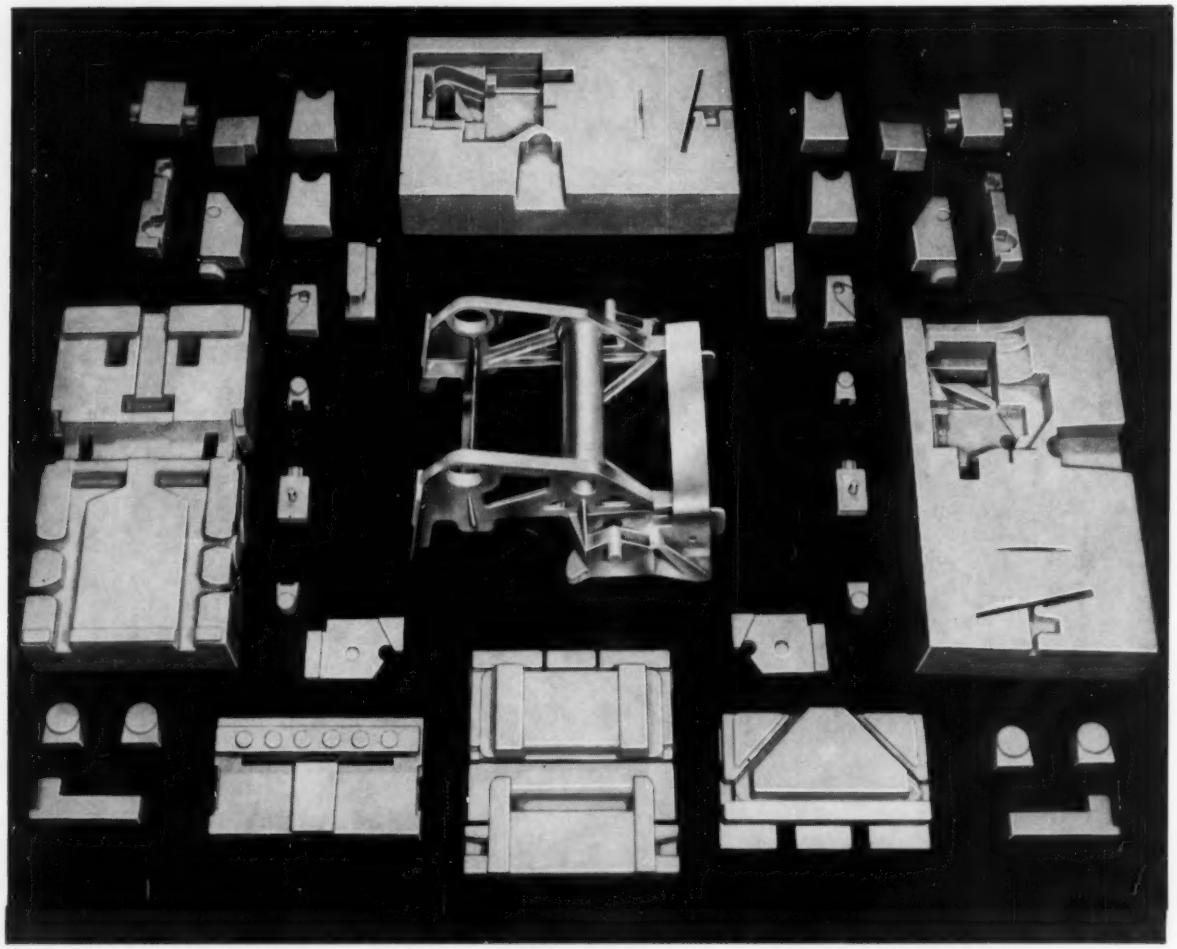
ARE **TOUGHER** THAN OTHERS!

And nobody has all the answers! Nevertheless, the men who staff our foundry service department have been able to solve many ferrous casting problems . . . are well-qualified by experience and training to help you.

Ohio Ferro-Alloys foundry service men are ready, willing and able to discuss your casting problem, even if it does not relate to alloying. They talk your language, they know the foundry business and they have the kind of attitude that says: "Our job isn't finished until yours is."

QUALITY SERVICE DEPENDABILITY

Ohio Ferro-Alloys Corporation
Canton, Ohio



How RCI FOUNDREZ CORE BINDER Helped AMERICAN BRAKE SHOE Meet MIL-C-21180A

To produce the strong, dimensionally precise, lightweight casting shown above, the Light Metals Department of American Brake Shoe Company in Mahwah, New Jersey called upon two of the latest advances in metalworking technology . . . Ductaluminum, a relatively new and stronger aluminum alloy and RCI's FOUNDREZ liquid amino-aldehyde core binder. Used together, they now make it possible for foundries to meet military specifications in castings of this complex nature. ■ Thirty-six individual cores (see illustration) are required to produce this jet canopy casting. And why does American Brake Shoe choose RCI FOUNDREZ for this application? Four factors are involved: **1.** *RCI's liquid amino-aldehyde core binder provides better binder distribution in the core sand which contributes to exact casting dimensions and keeps surface defects at a minimum.* **2.** *The advantage of dielectric baking, and the high core strength obtained, increases core production and speeds core handling.* **3.** *Excellent core knockout and collapse qualities, at the lower pouring temperatures of aluminum, speed production and reduce the cost of finishing.* **4.** *RCI's reputation for on-time delivery and prompt technical service.* ■ If you are pouring metal castings at temperatures below 2700° F, we suggest you investigate the improved core properties offered by RCI's FOUNDREZ liquid amino-aldehyde binder. Reichhold will deliver this unique resin to you from seven convenient shipping points in tank cars, tank trucks or drums. Write today for Technical Bulletin F-2-R for full data on RCI's FOUNDREZ 7600 series.

Creative Chemistry . . .
Your Partner in Progress

RCI

REICHHOLD
FOUNDRY PRODUCTS
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

FOUNDREZ *Synthetic Resin Binders*
COROVIT *Self-curing Binders*
CORCIMENT *Core Oils*
CO-RELEES *Sand Conditioning Agent*
REICOTE *Sand Processing Agent*

Circle No. 170, Pages 143-144